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ELECTRICAL ILLUMINATION AT THE PAN-AMERICAN EXPOSITION.

By Edward Hale Brush.

There is much interest among electricians and that part of the public which gives attention to the progress of science generally in the electrical illumination to be effected at the forthcoming Pan-American Exposition at Buffalo. Much in the way of beautiful and sensational and novel effects in illumination has been promised. The test recently made of the lighting scheme for the Exposition shows that the prophecies made were not too alluring, for the success of the scheme is seen to be even beyond expectation.

Now that one of the magnificent buildings, that of Machinery and Transportation, has been covered with countless lamps, which at night can be made to glow with a rich and soft radiance, a foretaste is given of what the grand ensemble will be when all the buildings surrounding the Court of Fountains, including the stately Electric Tower, are thus equipped and the electric current is turned on for their illumination.

The great advance made in methods of electric lighting during the past decade renders it possible to effect an illumination at the Pan-American more beautiful, more glorious, more wonderful, than anything heretofore conceived or even dreamed of by the human imagination, unless in flights of poetic fancy describing the divine illumination of the New Jerusalem.

A method has been devised for turning on the lights at this Exposition in Buffalo whereby the strength of the light is gradually increased, until the full candle power of the lamps is reached. From a glow that is scarcely perceptible the electric energy is increased in force until the extreme of brilliancy is reached.

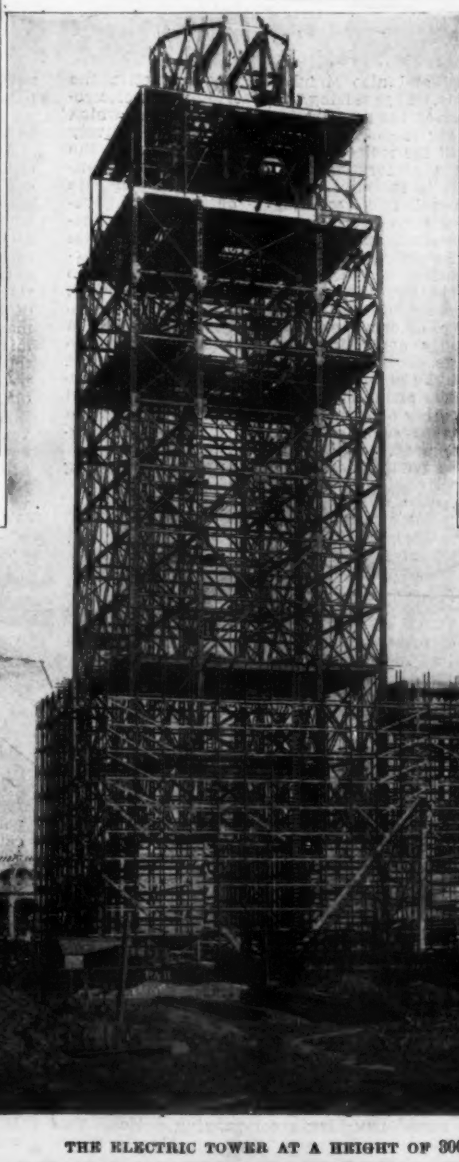
This almost imperceptible increase in the power of the lights as they are turned on will constitute one of the charming effects of the whole scheme, of which the visitor will never tire. Mr. Henry Rustin, Chief of the Electrical and Mechanical Bureau, and his associates are studying to make a brilliant success of this feature of the Exposition. Mr. Rustin obtained some valuable experience in this field while in charge of the lighting effects at the Omaha Exposition.

The idea should not obtain that this illumination is to be of the nature of a fierce, dazzling glare of strong light from arc lamps. On the contrary, the lighting will be so soft and agreeable that while pleasing in the extreme the sensation experienced in viewing the illuminations will not produce any effect such as one gets in trying to look at too strong a light. This desirable end will be attained through the use of the incandescent lamp as the unit, in place of the arc light. At other expositions arc lights or

"GODDESS OF LIGHT," ELECTRIC TOWER.

NORTHERN FAÇADE, MACHINERY BUILDING.

BAND STAND ON PLAZA.



THE ELECTRIC TOWER AT A HEIGHT OF 300 FEET.

PROGRESS OF THE PAN-AMERICAN EXPOSITION.

large units of gas or kerosene lamps have been used, and consequently it was not possible to produce the thorough diffusion of light which will be attained at the Pan-American Exposition by the use of well distributed small units. Instead of a few intense points of light, there will be myriads of these small but nevertheless powerful incandescent lamps outlining the towers, pavilions, caves, and other exposed points of the principal buildings surrounding the Court of Fountains. Upon and about the Electric Tower the lights will be, of course, most brilliant and glorious, while the basin in front of the Tower, the cascade falling into it from a height of 70 feet, and the basin of the Court of Fountains, with its fountains and cascades, as well as the Plaza and Esplanade and buildings surrounding, will be grandly illuminated with these same incandescent lamps used in a way to intensify the charm of the whole magnificent scheme.

The wiring of the Machinery and Transportation Building for the illumination has been completed. That of several other buildings is nearly so.

When the lights were turned on the Machinery building a few nights ago, the effect was awaited with much anxiety and expectancy. The result was all that could have been desired; indeed, it surpasses expectations, for the charm of this kind of illumination I am sure has never been brought out in such a way before.

The Machinery building is 500 feet long, and it is nearly 200 feet to the topmost points of the splendid towers surmounting it, which remind one so strongly of a campanile of some ancient Mexican cathedral. With rows of lights outlining all the architectural features of this great structure and bringing out the beauty of its colors, which can be seen to even greater advantage than under the light of the mid-day sun, the effect is charming beyond the power of any words one can think of for purposes of description.

Bear in mind that this is but one of a large number of buildings which will be thus illuminated next summer, and that the Electric Tower will be the most glorious spectacle of all, rising as it will to a height of 391 feet, and bearing upon its summit a statue of the Goddess of Light to crown the whole wonderful scene.

To give variety and novelty to the illuminations and increase the fairy-like effect at night, floating lights will be used in the fountain basins. In the basin in front of the Electric Tower there will be not only floating incandescent lamps, but also an illumination of most striking and fanciful character to be achieved by placing beneath the water of the basin 94 large-sized search lights, casting colored lights on the water effects, and also bringing out the fact that these colors are so arranged as to be constantly changing. This combination of electrical and hydraulic effects and introduction of ingenious devices for increasing the marvels of the scene will secure results such as are attained by experts in the production of spectacular scenes on the stage. But there will be this important difference that instead of being confined to a space like the stage of a theater, 50 feet wide, we will say, and possibly 100 feet in depth, the space thus illuminated will be about 2,000 feet in length by nearly 700 in width, while some of the scintillating lights will reach an altitude of nearly 400 feet in their ambition to outrival in beauty the twinkling stars of the firmament overhead.

The fountain display will call for the use of 35,000 gallons of water per minute, and the number of incandescent lamps used in producing the illumination in and about the Court of Fountains, Plaza, and Esplanade will be over 200,000. This does not include the arc lamps used in the buildings and at some points on the grounds, nor the many incandescent lamps used by concessionaires on the Midway and by private exhibitors.

One of the Midway concessions, the Thompson Aerio-Cycle, will alone use 2,000 incandescent lamps. Other Midway features will be profusely lighted, which will considerably increase the total number of lights used in the illumination of the buildings and grounds as a whole.

About 400 miles of wire will be used in the insulation of the lamps for the illumination in and around the Court of Fountains, which expressed in another fashion means about 250 tons of insulated copper wire of all sizes.

The electric energy for the production of this vast illumination will be obtained partly from Niagara Falls. From the harnessed Niagara 5,000 horse power will be furnished for Exposition uses, and about 5,000 more horse power will be generated on the grounds for the turning of the wheels and the lighting of the myriads of lamps. The service already arranged for contemplates the use of gasoline for motive power, of gas both under boilers, producing steam, and in gas engines, producing energy as well as the utilization of the water power of Niagara. Thus it can be seen that the Pan-American Exposition enjoys the advantage of a greater number of resources of power than has been possessed by any exposition of the past.

THE TELEGRAPHONE—A MAGNETIC SPEECH RECORDER.

By VALDEMAR POULSEN.

FOLLOWING is a description of the principles and the arrangement of my invention which I have called the telegraphone. A steel wire (piano wire), *AB*, about 1.5 m. (5 feet) long and 0.5 mm. (one-fiftieth inch) in diameter is stretched on a board, Fig. 1. Along it can slide the electromagnet, *E*, which embraces it with one of the poles, Fig. 2. The core of the electromagnet is a piece of soft iron wire about 8 mm. (one-third inch) long and 0.75 mm. (three one-hundredths inch) in diameter, and the electromagnet itself is in series with a battery and a microphone, or is connected to a transformer in the microphone circuit. At the beginning of an experiment the wire should be completely unmagnetized.

If, while the electromagnet is sliding along the wire with a velocity of about 1 m. per second, the microphone is spoken into, the current fluctuations produced register themselves by means of the electromagnet on the steel wire. If now the electromagnet is connected up with a telephone and made to travel over the wire again, the telephone repeats what was spoken into the microphone. Thus, owing to the great coercive strength of steel, there has been impressed on the wire in undulations, so to speak, of magnetization, a kind of writing which is permanent, and faithfully records the articulations of the voice. When *E* is put, now, in direct connection with a moderately strong battery and is made to pass once more over the wire the magnetic writing is obliterated under the influence of the constant magnetizing force, which is great compared with the intensity of the writing magnetic forces.

The wire, *AB*, is too short to contain many words. In order to obtain a larger capacity a very long piano wire is wound very firmly round a drum having a fine spiral groove on its surface, and the piano wire follows this spiral groove. Parallel with the axis of

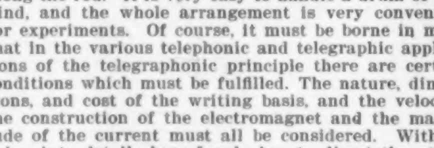


FIG. 1.

the drum there is a rod upon which a kind of sleeve can slide. The electromagnet is fastened to this sleeve. When the apparatus is in operation, the electromagnet embraces with one of its poles, or with both, the steel wire, Fig. 3, and during the rotation this steel wire itself pushes the electromagnet and the sleeve along the rod. It is very easy to handle a drum of this kind, and the whole arrangement is very convenient for experiments. Of course, it must be borne in mind that in the various telephonic and telegraphic applications of the telegraphonic principle there are certain conditions which must be fulfilled. The nature, dimensions, and cost of the writing basis, and the velocity, the construction of the electromagnet and the magnitude of the current must all be considered. Without going into details here I only beg to direct the attention upon some essential points concerning the three proceedings, viz., the inscription, the reproduction, and the obliteration.

Most frequently the inscription is effected by means of a polarized electromagnet, but the polarization and the degree of the polarization must not be arbitrary. Let, for instance, the electromagnet, by means of which the writing is to be performed obliterate a prior magnetic record and also simultaneously magnetize the writing basis. Then during the inscription the electromagnet is given the polarization opposed to that which it had during the obliteration. In this way a lively movement of the molecular magnets is obtained at the very moment of forming the writing. The susceptibility seems to increase very much in that magnetic status nascendi, and every shade of the writing becomes extremely perceptible. Ordinarily the polarization of the writing magnet is only a very small fraction of that of the obliterating one. The nearer its polarization approaches to the neutralization of that of the writing basis, however, the feebler may be, of course, the polarization of the obliterating magnet. The coercive force determines the degree of polarization which exactly neutralizes the magnetization of the writing basis. It is found that the writing is somewhat weak when the polarization of the electromagnet during the process of inscription is just equal to that used in the preceding obliteration. In order to polarize the electromagnet a constant current or a permanent magnet may be used.

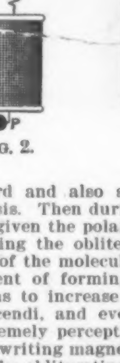


FIG. 2.

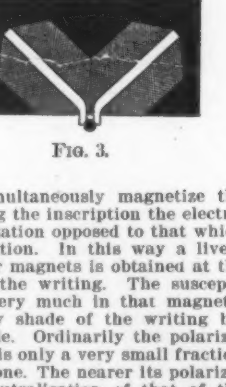


FIG. 3.

If the positive and negative curves of an alternating current differ, their faculty of producing the writing may equally differ. This explains the peculiarity that the direction of the primary current with a certain polarization of the writing basis may sometimes influence the writing which, in the secondary circuit, is performed by an unpolarized electromagnet. This is owing to the lack of uniformity in the manner in which the resistance of the microphone is increasing and diminishing. The inequality here spoken of is perhaps the more considerable the more the mobility of the carbon granules is considerable.

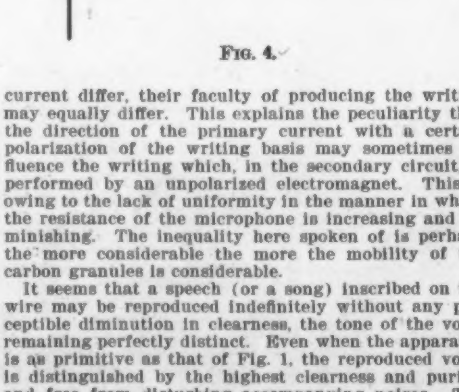


FIG. 4.

It seems that a speech (or a song) inscribed on the wire may be reproduced indefinitely without any perceptible diminution in clearness, the tone of the voice remaining perfectly distinct. Even when the apparatus is as primitive as that of Fig. 1, the reproduced voice is distinguished by the highest clearness and purity, and free from disturbing accompanying noises. The telegraphones of more recent date are able to reproduce with the greatest exactitude not only words spoken or sung into the microphone, but also whispers and even the feeble sounds of respiration.

The writing is completely obliterated by passage through a magnetic field of sufficient strength. Ordinarily it is sufficient to let the writing basis pass the writing magnet or another small electromagnet energized by a current from two or three cells. If a speech, however, be inscribed by means of an unpolarized magnet on a writing basis already written upon there results, as a rule, not an obliteration, but an interference.

Besides common piano wires, steel ribbons and nickel wires have been used as writing bases. The dimensions of the steel ribbons were 3 mm. by 0.105 mm. (one-ninth inch by one-fiftieth inch). The steel ribbon passes from a roll to a second receiving roll, where the layers of the ribbon may cover each other without the writing being destroyed. As to this last point, it has been proved by experience that the magnetism does traverse the ribbon, though as a rule, there is sufficient air space between consecutive layers to afford nearly complete protection. With a speed of about 1 m. (3 feet) per second, 0.154 liter (one-fiftieth cubic foot) of steel is needed for a speech lasting an hour. Instead of ribbon, a fine piano wire unrolling from one place to another may be used. In some cases nickel may with perfectly good effect be used as a writing basis, which fact is in accordance with the known properties of this metal as regards permanence for weak magnetizations, and demonstrated by A. Abt. The great dependence on mechanical influences which is characteristic of the magnetic state of nickel demands, however, careful handling of the nickel wire. It is not likely that the common steel used hitherto is exactly the most suitable for telegraphonic purposes; most probably other and better kinds are to be found.

I have no intention of speaking of all the various specifically phonographic applications of the telegraphonic principle nor of the constructive differences in connection with such applications. Nevertheless, I think that the following arrangement ought to be sketched: a long steel ribbon is stretched between two rolls which can rotate at a rather considerable speed. The ribbon passes a series of electromagnets of a speed regulated according to the circumstances. The electromagnet, *E*, inscribes words, music, etc.; the other electromagnets—"the reading magnets"—reproduce the communications in the telephone of each hearer; and, finally, the obliterating magnet, *V*, equalizes the magnetic variations of the ribbon ("telephonic newspaper," Fig. 5). As using does not weaken the writing, we are able to intercalate any number of reading magnets.

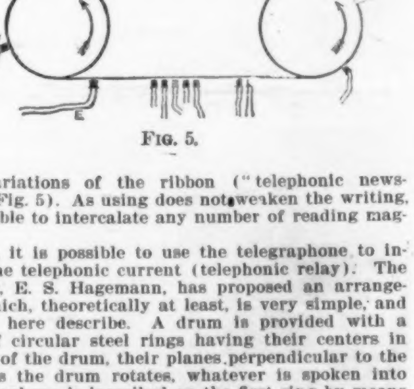


FIG. 5.

Again, it is possible to use the telegraphone to increase the telephonic current (telephonic relay). The engineer, E. S. Hagemann, has proposed an arrangement which, theoretically at least, is very simple, and which I here describe. A drum is provided with a series of circular steel rings having their centers in the axis of the drum, their planes perpendicular to the axis. As the drum rotates, whatever is spoken into the microphone is inscribed on the first ring by means of a writing magnet. By means of a series of reading magnets placed on the first ring, the words are transmitted to the other rings, which synchronically carry their equally formed writings past their reading magnets, duly connected together, and afterward past obliterating magnets (Fig. 6).

An elegant method of compensation has been invented by the engineer, P. O. Pedersen, and allows several speeches to be intermingled, so that they can afterward be reproduced separately. As it is not feasible to describe this method satisfactorily in a few words, I shall not speak further of it here. Later,

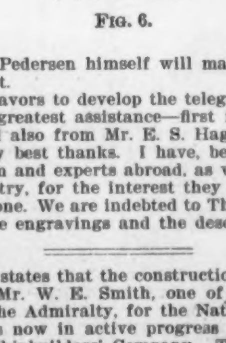


FIG. 6.

perhaps, Mr. Pedersen himself will make a communication about it.

In my endeavors to develop the telegraphone I have received the greatest assistance—first from Mr. P. O. Pedersen, and also from Mr. E. S. Hagemann. I owe them both my best thanks. I have, besides, to thank the Institution and experts abroad, as well as those of my own country, for the interest they have shown in the telegraphone. We are indebted to The London Electrician for the engravings and the description above.

THE Times states that the construction of the vessel designed by Mr. W. E. Smith, one of the chief constructors to the Admiralty, for the National Antarctic Expedition, is now in active progress at the yard of the Dundee Shipbuilders' Company. The ship, which is to be named the "Discovery," is to be barque-rigged and to have three decks. Accommodation for those on board will be provided under the upper deck. The stem will be of the ice-breaker type, with strong fortifications. The length of the vessel between perpendiculars is 172 feet; beam, 34 feet, and depth, 19 feet. The timbers are of oak doweled and bolted together and the keel, deadwoods, the stem, and the stemposts are also of oak. The planking is of American elm and pitch pine, and the inside beams are of oak. With the object of avoiding the magnetic influence of iron on the scientific instruments on board, it has been decided that for a considerable radius amidships the knees and fastenings shall be of naval brass. In case the "Discovery" should have to winter in the ice, a heavy wagon cloth awning of strong woolen felt is to be provided. The fittings and equipment of the vessel will be of the most modern type. The engines, which are to indicate 450 horse power, are to be constructed by Messrs. Gourlay Brothers & Company, Dundee.

CONTEMPORARY ELECTRICAL SCIENCE.*

PHOTO-ELECTRIC RAYS.—E. Merritt and O. M. Stewart have traced the connection between cathode rays and the particles discharged from negatively-charged bodies under the influence of ultra-violet light along lines resembling the famous investigations of Lenard (see The Electrician, vol. xlv., p. 358). For simplicity the authors call the streams of particles discharged through the influence of ultra-violet light "photo-electric rays," and they then proceed to show that they are of essentially the same nature as cathode rays. This is the conclusion already arrived at by J. J. Thomson, who has even determined the ratio e/m for these rays, and found it to lie between 5.8×10^6 and 8.5×10^6. The authors employed an arc lamp in place of a spark gap as a source of ultra-violet light, and their vacuum tubes were essentially the same as Lenard's, with a slanting side tube to direct the ultra-violet rays on to the cathode. Their magnetic deflection experiments led them to the conclusion that two kinds of particles are concerned in the photo-electric discharge: (1) The small rapidly moving corpuscles of the photo-electric rays, forming a fairly compact stream normal to the cathode; (2) the relatively heavy and slowly moving negative ions, which form a stream having the same general direction as the photo-electric rays, but much more diffuse and not appreciably affected by a magnetic field.—Merritt and Stewart, Phys. Review, October, 1900.

EFFICIENCY OF ACETYLENE FLAME.—A lengthy investigation both of the radiant efficiency and the total efficiency of the acetylene flame has up to the present yielded results which have led E. L. Nichols to make a preliminary announcement concerning them. The radiant efficiency, i. e., the ratio of luminous to total radiation, was computed both by the method of Melloni and by the spectroscope method, the latter consisting in the exploration of the spectrum and the comparison of the areas inclosed by the curve within and without the limits of visibility. The total efficiency, i. e., the ratio of luminous energy to total energy supplied, was computed by means of the heat of combustion, the amount of gas supplied, and a modification of Thomson's method. As regards the radiant efficiency, that was found to be 0.105, or practically the same as that of the arc light, which is equally "cold," and twice as "cold" as either the incandescent or the Welsbach lamp. The contrast with the radiant efficiency 0.32 of the vacuum tube remains, therefore, as great as ever. In the matter of total efficiency, on the other hand, the acetylene lamp stands very high. The figure given is about 0.02, or at least double the corresponding figure for the arc light. The magnesium flame alone, with its astonishing efficiency of 0.1, is superior to the acetylene flame.—E. L. Nichols, Phys. Review, October, 1900.

RESISTANCE OF A GALVANOMETER.—W. S. Davy describes what he believes to be a new method of measuring the resistance of a galvanometer. It is based upon the principle that if the terminals of a galvanometer are brought to a certain potential difference, and the resulting current through the galvanometer gives a certain constant deflection, then, if we double this potential difference, it will be necessary to double the resistance of the galvanometer circuit if we wish to maintain the needle at the same reading. Use may be made of the uniform fall of potential along a potentiometer wire. In this method, the galvanometer terminals would be placed in contact with points on the wire a suitable distance apart, and the deflection noted. This distance would then be doubled, and at the same time a resistance would be inserted in series with the galvanometer and varied until the deflection became the same as at first. Then, supposing the resistance of the part of the wire between the terminals is negligible in comparison, the resistance inserted will be the same as that of the galvanometer. If it is not negligible the effect of the potentiometer wire may be determined by taking points three times as far apart as the original points, and observing what resistance is then necessary to keep the galvanometer current the same.—W. S. Davy, Phys. Review, October, 1900.

COHERER MATERIALS.—A large variety of metallic powders have been examined by T. Mizuno with regard to their behavior in coherers. The point chiefly studied by the Japanese physicist is the change produced by several successive sparks, and for this purpose he noted the value of the resistance after every spark up to 25. He finds that in platinum, lead, nickel, aluminium, cadmium, copper, steel, and potassium coherers, the action of electric waves is to reduce their resistances at first to a large extent, and then this reduction continues, though with some intermediate rise and fall, until the resistances assume certain final values. In the case of tin, bismuth, zinc, antimony, and especially iron, the resistances are diminished at first, but soon afterward the changes become very irregular, the diminution and increase occurring at random. But it often happens that zinc, lead and potassium coherers, as well as those made of electric fuse, suddenly assume an infinite resistance. In the case of coherers with mixed metals, such as iron with silver, cadmium, Rose's or Wood's metals, and also silver with Wood's metal, the mode in which the resistance changes seem to be chiefly governed is shown by the percentage ratio of the constituents. In fact, the history of each coherer presents the character which would belong to the predominant constituent.—T. Mizuno, Phil. Mag., November, 1900.

ELECTRIC TRACES ON SENSITIVE PLATES.—V. Schaffers has made an elaborate study, suggested by Leduc's reproduction of globe lightning on a small scale, concerning the manner in which photographic plates, or plates of a similar constitution, are influenced by the discharge from an influence machine, conveyed through electrodes in the shape of needle points in contact with the film. A great variety of actions may be observed, according to the arrangement of the electrodes, the current strength, and the material of the film. Tracings of the lines of force are obtained with mercuric chloride suspended in gum or silver bromide in gelatine. Zones of various degrees of intensity, arranged along equipotential lines, are obtained with silver chloride suspended in gum, or silver bromide emulsion in starch. Gold iodide gives beautiful diagrams of continuous lines of force. But the most interesting phenomenon is that of the ball of light which emerges from the negative electrode, passes for a small distance along the glass underneath the film, and proceeds more or less slowly toward the positive electrode, fusing the medium and reducing the salt as it goes along. It does not necessarily move along the lines of force, but chooses the line of least resistance, and may cut across previous traces at an acute angle. The ball may be, of course, a simple cathode phenomenon, produced at the head of the track of reduced salt, which forms a prolongation of the cathode.—V. Schaffers, pamphlet, printed by Hermann, Paris, 1900.

CATHODE-RAY COLORATION.—Some colorations resembling those due to the oxidation of steel have been obtained with cathode rays by W. B. Von Czudnochowski. He uses a spherical bulb and a spherical cathode, and exposes crystals of fluorspar or rock salt to the radiation from the cathode just below the point at which the rays converge. The violet coloration of colorless fluorspar has long been known, but with the arrangement described the uniform bronze color seen by reflected light is replaced by colored rings. The extreme edge appears bronze colored; then comes a full yellow, then red, and, lastly, a bluish-violet in the center. On further exposure, the rings widen out and a new system is developed in the center. After fifteen minutes' exposure colorless Tyrolese fluorspar shows the following rings, counting from the edge: Silver-gray, yellow, orange, brown, blue. Northumberland fluorspar and rock salt show similar colors, which are, however, masked, in the case of the latter, by the uniform brown coloration of the whole surface. The regular series of colors appears to be gray, yellow, orange, brownish-yellow, violet, yellow, red, violet. The series observed in steel is straw-yellow, orange, red, dark blue, light blue, pink, green, water blue, pale yellow. Newton's rings follow the reverse series.—W. B. Von Czudnochowski, Physik. Zeitschr., November 3, 1900.

*Compiled by E. E. Fournier d'Albe in The Electrician, November 16, 1900.

THE TREATMENT OF LONDON SEWAGE.*

WHEN some years since, the raw sewage of London was regularly poured into the river in the neighborhood of the city, the road detritus and putrescible fæcal matter which were delivered in the sewage settled on the river bed and foreshores. The road detritus tended to permanently reduce the depth of the river; while the putrescible matter, arriving faster than it could be removed by the river or could be destroyed by inoffensive bacterial action, accumulated as a deposit on the foreshores and floated in masses of thick scum on the river. It there underwent foul putrefactive changes, rendering the river most offensive to those who navigated it or lived and worked near its banks, and almost intolerable in summer weather, even to those who crossed its bridges. That this result was inevitable will be understood when it is remembered that the sewage consists of the whole of the water-supply and rainfall over the metropolitan area which have been charged with varied refuse matters of our streets, our houses, and our manufactories.

The nuisance was removed by taking the sewage fifteen miles below London. Since this was found insufficient, the sewage was subsequently subjected to chemical treatment and sedimentation before it was allowed to flow into the river. The treatment ultimately adopted, and still in vogue, consists in straining or "screening" off the larger solid matters and then mixing the sewage with solutions of lime and sulphate of iron; the chemical precipitate thus produced is then allowed to settle, together with the finer particles in the sewage, by sending the sewage slowly through parallel channels on its way to the river. The settled matter, or "sludge," is sent in tank-steamers to be discharged out at sea beyond the river's mouth; and the fairly clear "effluent" passes constantly into the river from the northern outfall (Beckton or Barking) and the southern outfall (Crossness) in two streams, which jointly deliver over 200,000,000 gallons every twenty-four hours into the river, and which probably constitute the most important tributaries of the lower Thames near London. Since these processes of chemical treatment and sedimentation have been adopted, the foreshores of the river have become clean, the outrageous foulness of the stream has ceased, and those who live on and near the Thames unanimously express their approval of the improvement effected.

It must be remembered, however, that the effluent of the sewage, after it has been freed from visible foul matter, still contains in invisible solution a large amount of putrescible substance, which may, under suitable conditions, lead to serious foulness in the stream. The effluent at present discharged into the river is practically only clarified sewage. As long as putrefactive changes are delayed by low temperature of the river water, and an ample flush of upper river water comes down to dilute this effluent and to carry it rapidly out to sea, no sensible foulness occurs in the main stream. But in summer time, when high temperature hastens putrefactive changes and diminishes the amount of oxygen dissolved in the river water, and when the flush of water from the upper river is diminished by drought and by the abstraction of larger volumes of the water by the water companies, the condition of portions of the lower river frequently closely approaches that necessary to cause offense. There can be no doubt that as the volume of sewage effluent increases, and the abstraction of upper river water for water-supply also increases with the increasing population, these portions of the lower river must pass more frequently into a condition bordering upon or actually causing foulness. It is, therefore, prudent to be prepared to adopt without delay a method of treatment of the London sewage which shall meet the requirements of an increasing population, and shall enable the more ample effluent to be discharged into the river in a state of greater purity than is at present secured.

As far back as 1893, the Main Drainage Committee of the County Council, on the advice of their chemist, Mr. Dibdin, started a large scale experiment on the bacterial purification of sewage, the purification being applied to the effluent from chemical treatment and sedimentation. This experimental treatment has been continued by the committee, on my own advice, and has been considerably extended in its scope. The committee also consented to the association of the eminent bacteriologist, Dr. Houston, with me in these experiments during the three years of their progress. The results which have been obtained have been published by the London County Council in the form of a series of reports which I have laid before them from time to time. The general conclusion to which they point is that the settled sewage may be purified to a far greater degree than it is by the present treatment, by encouraging the spontaneous purifying action of the bacteria which are present in the sewage itself. The effluent thus produced, without the intervention of chemicals, remains free from foul putrefaction and is able to support the life of fish; in these and in all other respects it is greatly superior to the effluent which is at present discharged into the river. The minute organisms, known as bacteria, exist to the average number of 300,000 per drop of sewage. They only require to be placed under suitable conditions in order to effect the rapid and inoffensive resolution of the putrescible matters of the sewage into harmless and inoffensive products.

The general conclusions derived from the experimental bacterial treatment of raw sewage at the outfalls of the London sewage into the Thames are as follows:

(1) The following results were obtained by treating the raw sewage bacterially in coke-beds. In the process adopted, the sewage was allowed to flow into large tanks which contained fragments of coke about the size of walnuts. As soon as the level of the liquid had reached the upper surface of the coke-bed, its further inflow was stopped, and it was allowed to remain in contact with the bacteria coke surface for two or three hours. It was then allowed to flow slowly away from the bottom of the coke-bed. This outflowing liquid constituted the "sewage effluent." After an interval of from three to seven hours, the processes of emptying and filling the coke-bed were repeated with a fresh portion of sewage. The coke-bed was at first filled in this way twice in every twenty-four hours, but later on it was filled three and four times in twenty-four hours.

(2) A considerable purifying action has been effected by the coke-bed. This is produced by the introduction of bacteria from the sewage. The maintenance of the purifying action is due to the presence of bacteria or their enzymes upon the coke surfaces, and to the adequate aeration of these surfaces by frequently exposing them to the oxygen of the air.

(3) The oxygen undergoes absorption by these surfaces, and the aeration of even the lowest portions of a deep coke-bed seems to be satisfactory in the above method of working, since the air present in the interstices of the coke, between two fillings with sewage, usually contains as much as 75 per cent of the amount of oxygen present in the air.

(4) Raw sewage, which had been deprived of its larger particles by screening it through coarse gratings, lost practically the whole of its suspended matter by remaining in such a coke bacteria bed for two or three hours. It appears that the suspended particles of fæcal matter underwent liquefaction by the bacteria, since they did not collect upon the surface of the coke.

(5) The sand and grit and finer mud arising mainly from the wear of road surfaces, however, were deposited upon the coke surfaces, and gradually reduced the capacity of the coke-bed.

(6) Hair, fibrous matter and woody fiber derived from the wear of wooden street pavements, and particles of chaff and straw mainly derived from the dejecta of horses employed in the street traffic, were also deposited upon the coke surfaces and gradually choked the coke-bed. These substances, which consist mainly of cellulose, are apparently only acted upon by bacteria with extreme slowness under the above conditions. They arrive, however, in a water-logged condition, and rapidly settle down from the sewage if its rate of flow is reduced.

(7) In dealing with the sewage of the metropolis, it seems best to submit the roughly screened raw sewage to a somewhat rapid process of sedimentation, in order to allow these suspended mineral and cellulose matters (5, 6) to subside; and then to pass the sewage direct into the coke-beds. The dissolved matters and the small amount of suspended matters which are still present in the sewage are then readily dealt with by the bacteria of the coke-bed, and no choking of the beds occurs.

(8) The sewage effluent which is thus obtained from the coke-beds is entirely free from offensive odor and remains inoffensive and odorless even after it has been kept for a month at summer heat, either in closed or open vessels. It is clear, except when a turbidity is produced by fine mud particles washed down by heavy rain. Many pond and river fish have been kept in the constantly renewed effluent for a month, and have been found to be perfectly healthy at the end of that period.

(9) The chemical character of this effluent may be

* Abridged from a paper read before the Society of Arts, on December 12, 1900, by Prof. Frank Clowes, and published in Nature.

indicated by stating that on an average 51.3 per cent of the dissolved matter of the original sewage, which is oxidizable by permanganate, has been removed by the bacteria, and that the portion which has been removed is evidently the matter which would become rapidly offensive and would rapidly lead to de-aeration of the river water if it were allowed to pass into the river. The above percentage removal (51.3) was effected by coke-beds varying from 4 to 6 feet in depth. A similar bed, 13 feet in depth, has proved more efficient, and has for some time produced a purification of 64 per cent, while an old bed, 6 feet in depth, has given a purification of 86 per cent. A repetition of the treatment of the effluent in a second similar coke-bed has produced an additional purification of 19.3 per cent, giving an average total purification of 70.6 per cent (See Table I.). It should be noted that the above purification is reckoned on the dissolved impurity of the sewage; the suspended solid matter is not taken into account. No difficulty has been found in maintaining this bacterial purification.

TABLE I.—RELATIVE IMPURITY AS ESTIMATED BY PERMANGANATE.

Raw sewage deprived of its suspended matter...	3.596	Percentage purification calculated on clear raw sewage.
Effluent from chemical treatment.......	3.070	16.9
Effluent from single bacterial treatment.	1.790	51.3
Effluent from double bacterial treatment.	1.187	69.2
River water (high-tide)......	0.550	....
River water (low-tide)	0.429	....

(10) The bacteriological condition of the effluent corresponds in the main with that of the raw sewage. The total number of bacteria undergoes some reduction in the coke-beds, but the different kinds of bacteria which were present in the sewage are still represented in the effluent.

(11) The introduction of such a sewage effluent into the lower Thames is unobjectionable. The river water at the points where the effluent is discharged is uniformly muddy; it is always brackish and frequently salt to taste, owing to the presence of tidal sea water. It is, therefore, not capable of being used for drinking purposes. The effluent would certainly cause no deposit upon the river bed, and would ordinarily tend to render the muddy river water more clear by mixing with it. No offensive smell would be emitted by the effluent as it is discharged into the river. And, although the effluent contains more organic matter than the river water does, the bacteria which it contains would slowly and inoffensively remove this organic matter from the effluent after it has been introduced into the river. The effluent would be suitable for the maintenance of healthy fish-life.

INTENSIVE LIGHTING WITH KEROSENE.

The Kitson system of lighting with kerosene originated a few years ago in the United States, and soon came into great favor in numerous cities by reason of the quantity of very bright light that it diffuses in a wide zone around the burners, and also because of the saving that it permits of effecting.

This system, which figured at the Exposition of 1900, is at present being experimented with by the city of Paris upon the Quai des Tuileries. The principle upon which it is based consists in the use of a definite

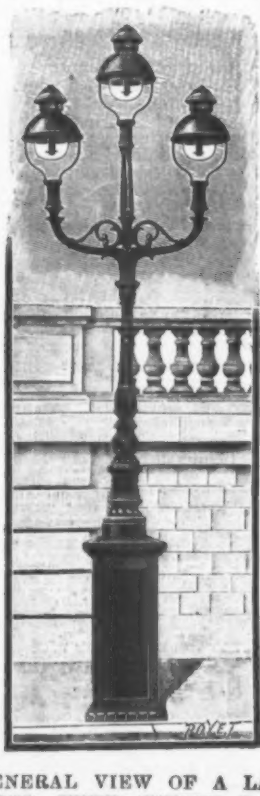


Fig. 1.—GENERAL VIEW OF A LAMP POST PROVIDED WITH KITSON LAMPS FOR EXPERIMENTS IN LIGHTING ON THE QUAI DES TUILERIES.

mixture of air and vaporized hydrocarbon which ignites and raises an Auer mantle to incandescence.

Fig. 1 gives a general view of the type of candelabrum adopted for the experiments above alluded to. In the base of the lamp post there is a cylinder which contains the kerosene, and is in communication with the lamps placed above. Fig. 3 gives an external view of one of these lamps, and Fig. 4 a section showing all the details. The cylinder, *A*, containing the kerosene is provided at the side with a level, *J*, that shows at every instant the quantity of hydrocarbon that exists in the reservoir (Fig. 2).

At *B* is seen a pump by means of which there is forced into the top of the cylinder a certain quantity of air until a definite pressure of about three or four atmospheres is reached. A pressure gauge placed at the side of the cylinder gives necessary indications. A tube, *C*, a few fractions of an inch in diameter is con-

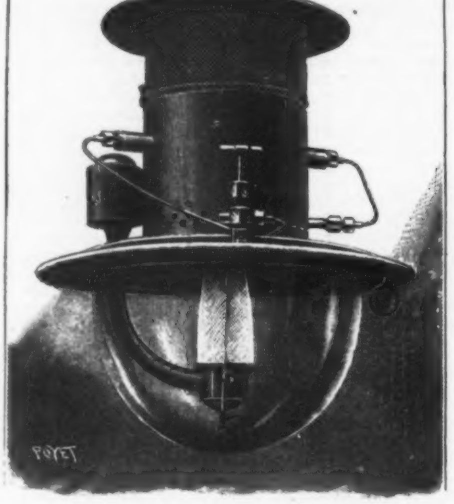


Fig. 3.—EXTERNAL VIEW OF THE KITSON LAMP.

nected with an external cock in communication with a tube that enters the kerosene in the interior of the cylinder. This tube is the one that leads the hydrocarbon to the lamp.

Upon the side to the left of the cylinder, *A*, is placed a small receptacle, *E*, filled with gasoline, and at which end two tubes, one of them, *F*, connected with the lamp in order to permit of the entrance of the gasoline, and the other, *D*, ending at *H*, in a cock placed upon the large cylinder. This cock permits of sending air under pressure into the gasoline receptacle, *E*. The air traverses the gasoline, becomes carbureted and makes its exit through the conduit, *F*, in order to reach the lamp.

At *G* may be seen two dry batteries mounted in circuit with an interrupter, *K*, and from the upper part of which start two wires.

The section in Fig. 4 will permit the operation of the lamp to be understood. The hydrocarbon, sent under pressure into the tube, *C* (Fig. 2), enters the lamp at *A*

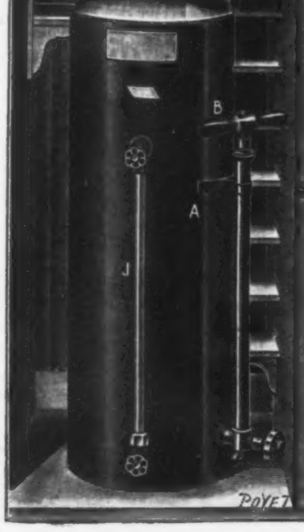


Fig. 2.—CYLINDRICAL PETROLEUM RESERVOIR.

(Fig. 4) and passes at *B* into a filtering tube, which frees it from the dust and other particles that it may contain. After this it enters a tube, *C*, which, heated by the incandescent burner, vaporizes it. After being reduced to a state of vapor, it reaches the entrance, *D* of a Bunsen burner, where it becomes mixed with the external air in proportions that are limited by a special aperture. The mixture of air and vaporized kerosene passes next under a mantle, where it burns and keeps the latter in an incandescent state.

In what precedes, we have supposed the lamp lighted, so that the heat disengaged by the incandescent mantle vaporizes the kerosene.

For the lighting, a few particular arrangements have been made for igniting the mixture upon its entrance into the burner. Two electric wires, *F* (Fig. 4), situated opposite one another, are connected with the wires that we have indicated in Fig. 2, and permit of obtaining a simple spark through the maneuvering of the

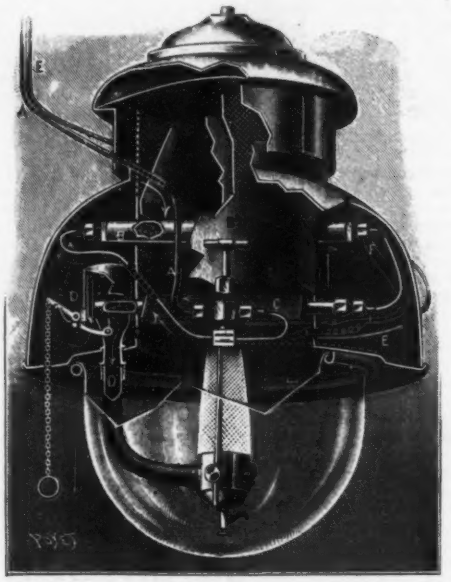


Fig. 4.—INTERIOR VIEW OF THE KITSON LAMP.

interrupter, *K*. This spark is formed in front of the tube, *E* (Fig. 4), that leads the carbureted air under pressure after traversing the gasoline receptacle (Fig. 2). The heat disengaged by the ignition of the carbureted air in contact with the electric spark suffices, after a few seconds, to light the burner. The practical operation of this lamp leaves nothing to be desired (as appears from the experiments that have already been made) and offers no danger of explosion. The very brilliant light diffused by the lamp on every side gives a very remarkable intensive illumination that permits of easily distinguishing colors and that is perfectly adapted for photographic operations.

In some laboratory experiments at the municipal service of the city of Paris, a lamp with an Auer mantle of large size gave a horizontal luminous intensity of 96.3 carcels with a consumption of 400 grammes of kerosene per hour, say 4.15 grammes per carcel-hour. The ordinary Auer mantle, which with gas gives a horizontal luminous intensity of 50 decimal candles, gives with the Kitson system a horizontal luminous intensity of about 500 candles, say ten times greater. As well known, the consumption of the Auer burner, under the above determinate conditions, is 2 liters of gas per candle-hour. The Denayrouse burner without motor gives a horizontal luminous intensity of 200 decimal candles, with an output of 260 liters of gas per hour, and its specific consumption is therefore about 13 liters of gas per carcel-hour. With arc lamps, despite the difficulties presented by photometric measurements and the variations in luminous intensity, according to a large number of diverse elements, we may reckon for the horizontal luminous intensity an expenditure of from 0.8 to 1 watt per candle. The mean specific expenditure of incandescent lamps is, as a general thing, from 3 to 3.5 watts per candle, although it is easy, through certain means, to diminish such value still further. These figures permit of establishing the comparative net cost of lighting by taking into account the selling price of kerosene, gas and electric energy. It is obvious that such price greatly influences the cost of lighting by means of these various systems. It may be admitted nevertheless that, under the conditions of the present price of kerosene, even in France, the Kitson system certainly remains one of the most economical.

The new lamp with its candelabrum is destined to prove very useful in a large number of circumstances. It will be advantageously applied on private property, in country houses, in villages, etc., and it is certain that it will be employed for exceptional lighting, such as that of work in the streets of a city that already possesses gas and electric apparatus. Nevertheless, there will be some hesitation about placing reservoirs of kerosene in profusion in a city; and we are led to think that the Kitson lamp will not be generally used in factories and stores, where the greatest precautions have to be continually taken against fires.—For the above particulars and the engravings we are indebted to La Nature.

The increase in the price of petroleum, and the decrease in the price of calcium carbide are said to be gradually enabling the latter to supplant petroleum as an illuminant. The Board of Trade Journal, quoting from a recent report of H.M. Consul at Stuttgart, states that at the end of 1899 about 170,000 jets of acetylene were installed in Germany, which—estimating the illuminating capacity of the acetylene flame at 40 normal candle-power—gives a total of 6,800,000 candles. This means that acetylene has been substituted for 180,000 petroleum flames, 21,000 oil-gas jets, and about 3,500 jets of other illuminants, without taking into consideration the large number of acetylene oil-gas jets used so extensively at present by the Prussian railways.

EXPRESS COMPOUND LOCOMOTIVE, SOUTHERN RAILWAY OF ITALY.

THE locomotive illustrated in our present number presents, says The Engineer, a remarkable departure from the standard practice of the Southern Railways of Italy or Adriatic lines of the Strade Ferrate Meridionali.

Just built by the company's works at Florence from the plans of Signor Plancher, assistant chief engineer of rolling stock, it is intended for conducting a service of trains of 260 tons net weight, and ordinarily composed of six vestibule cars and a luggage van, at speeds averaging fifty miles per hour.

With the view of obtaining a grate area in proportion to a very large boiler the fire-box was planned to stand above the frames, and the boiler was kept low by making the grate a level one. As this meant more difficulty in maintaining an even fire under the brick arch, the grate was given in width what is now obtained in fire-boxes by length, and as a consequence the six-coupled drivers had all to be placed where their restrictive limits were of no moment, underneath the boiler. To shorten the total length of the engine the space beneath the fire-box, usually taken up in modern locomotives by a single bearing wheel, was very conveniently employed for a long wheel-base bogie, and that, too, without relieving the nearest coupled wheels, in spite of their close proximity, of the weight required for adhesion. The bogie thus placed required for safe running the chimney end of the locomotive to become the trailing end—or precisely the same mode of running as is done as often as not by London suburban tank locomotives with bogies situated under their cabs. In place, however, of the usual side tanks, the coal bunkers are placed on each side of the footplate, not so much for the utilization by adhesion of their variable contents as for the necessities of the reversed direction of movement.

The advantages and disadvantages of running cab first are known to all suburban drivers. In this new express engine the admitted objections appear to be very fairly overcome in adding slightly to the recognized advantages, which may be summarized as, first, unobstructed view of the road in front; and, secondly, avoidance of exhaust steam and smoke in the driver's view, causing, besides, frequent blurring of the cab windows, to which points gained may be added that of direct, instead of return, draught through the tubes, one consequence thereof being less smoke in the cab when the steam is cut off. Moreover, the driver's convenience—of which engineers appear yearly to recognize more and more the importance—is increased by removing him from the hot boiler away from the movements and dusty work of the fireman beneath his eyes, and placing all which concerns his duties in the bay formed by the prow of the cab in front, where he can give undivided attention to the look-out.

This arrangement, giving more responsibility to the fireman in his charge of the boiler, might seem to prevent the latter from aiding the driver so well between times as he generally does, but this is again set off by the fact that the fireman and the driver can from their places see the full breadth of the road in front, besides each one having free to himself the entire width of the footplate at his own end, while the fireman has less distance to go and no turn to make in firing.

The trials so far made have fully satisfied the company as to the ease and safety with which the look-out is kept for signals, etc., in this way of running the cab. A cylindrical water reservoir of 3,300 gallons capacity replacing the usual tender is coupled up behind the chimney end and suffices for the regular runs to be made between Milan and Venice or between Milan, Bologna, and Porretta, taking water once en route.

So planned the grate area obtained with a short fire-box is 32.2 square feet, but the heating surface, with smooth tubes, is only 1,793 square feet; this heating surface is, however, an efficient one with the coal employed—Cardiff.

The boiler has a mean inside diameter of 4 feet 10 3-8 inches, and its capacity as a heat reservoir is 236.5 cubic feet, of which 81.2 is available for steam. At its lowest part the boiler is on a line with the rims of the 6 foot 4 3-8-inch driving and coupled wheels. The total weight available for adhesion is 42.8 tons, evenly distributed between the six-coupled wheels through equalizing levers, and notwithstanding the position of the bogie beneath the fire-box only 35 per cent. of the total weight (22.7 tons) is borne beneath the bogie tires, or about 4 per cent. more than with six-coupled express engines of standard Italian type.

There are four cylinders—two high-pressure on one side and two low-pressure on the other—so that one each of the high-pressure and low-pressure is lodged within the frames. The end of each high-pressure cylinder is coupled to the opposite end of the other high-pressure cylinder by crossed steam passages, one piston valve placed between the two cylinders distributing steam to both. The low-pressure group is arranged identically, each pair of cylinders maintaining the same relative independence that is generally only obtained by the use of four valves. The piston valves are situated above the outside cylinders and worked by Walschaert valve gears.

The boiler steam pipe is fixed obliquely across the smoke-box forward to the high-pressure valve chest, the exhaust from which is carried round the smoke-box in a horseshoe bend to the receiver. A small live-steam pipe—1 3-16-inch diameter inside—from the dome follows the course of the boiler dry pipe through the smoke-box, and then coming outside, is screwed to the base of the extension valve-rod guide on the high-pressure valve.

The extension valve-rod has a flat surface along a part of its length equal to a little more than the maximum travel of the valve, and is itself surrounded by a hollow rod or tube with a slot in its top edge ⅝ inch shorter than the maximum valve travel, and it is between these two rods that the live steam passes into the exhaust of the high-pressure valve chest, and thence to the receiver and low-pressure cylinders whenever the position of the valves is such that the low-pressure cylinders must make the initial movement. If, on the contrary, a high-pressure port is open to steam, then the entrance to the valve chest is blocked by one or the other of the steam-tight ends of the hollow piston-rod extension. This extension valve supplies live steam to the low-pressure cylinders so long as the regulator starting valve remains open.

The live steam inlet valve is combined with the regulator. This is of a novel pattern. The regulator-rod passing along outside the boiler turns in a closed stud bearing on the right-hand side of the dome, where a squared surface receives a short lever connecting it by an articulated rod to the regulator slide. The steam pipe inclined seating has two ports, 1⅜ inches wide and 1¼ inches wide, besides a short slot 5-16 inch wide, situated about ½ inch above the center line of the seating, the latter opening directly into a half-round cavity beneath, and in which is fixed the live steam pipe of the low-pressure starting apparatus. The regulator slide is double, one valve sliding on the other, the upper one being so barred that it always uncovers in starting and recovers in stopping two narrow slots of 5-16 inch and ¼ inch in the face of the loose slide beneath it, and which is, in reality, the main valve, since it has double the width of the upper slide. In operation the regulator works somewhat as follows: The first ½ inch of downward movement is confined to the top slide alone in merely uncovering the narrow 5-16-inch slot already mentioned, leading to the main steam pipe and high-pressure cylinders, at the same time uncovering the narrow ¼-inch slot in correspondence with the low-pressure starting apparatus. The two slides, now butting together, thenceforth move as one, and another ⅜ inch downward movement closes the live steam (L. P.) inlet in the seating, but uncovers the 1⅜-inch top port of the main steam pipe with the broad, loose slide, and that, too, before the narrow H. P. opening in the same slide has had time to get clear of the top port. In ⅛ inch more travel the 1¼-inch lower port also uncovers to the 1¼-inch slot in the loose valve, the double valve continuing to act as one ordinary regulator slide. In the return movement the first ½ inch is, of course, lost to the broad valve, the upper slide only covering up the narrow slots in the lower slide by the bars of the top slide, after which the two valves again act as one ordinary slide, and no steam can enter the starting apparatus in returning over the narrow (L. P.) slots in the steam pipe seating.

A Coale relief valve, connected with the receiver, limits the pressure therein to about 67 pounds, and an air valve, fitted on a branch of the same bracket behind the chimney, permits the return of air, and so prevents the production of vacuums in the receiver. To obviate a vacuum in the boiler dry pipe when the steam is cut off another suction or air valve is attached thereto, and mounted in front of the chimney.

Owing to the limited time available before sending the engine to Paris cylinder indicator diagrams have not so far been taken. The waste room of the steam passages has been so arranged as not to exceed the limits generally allowed in practice, it being in this case 10 per cent for the high-pressure and 7.5 per cent for the low-pressure, measured directly from the cylinders.

All mention made herein of the right and left-hand sides of the engine considers the fire-box as the front end and the chimney as the trailing end, which fact needs to be remembered to avoid confusion as to right and left. The cylinders are cast in couples, the one high-pressure and one low-pressure inside the frames being 1 3-16 inches thick, and the two corresponding ones outside 1 inch thick; the castings have longitudinal and vertical lugs by which they are bolted to the inside of the frames.

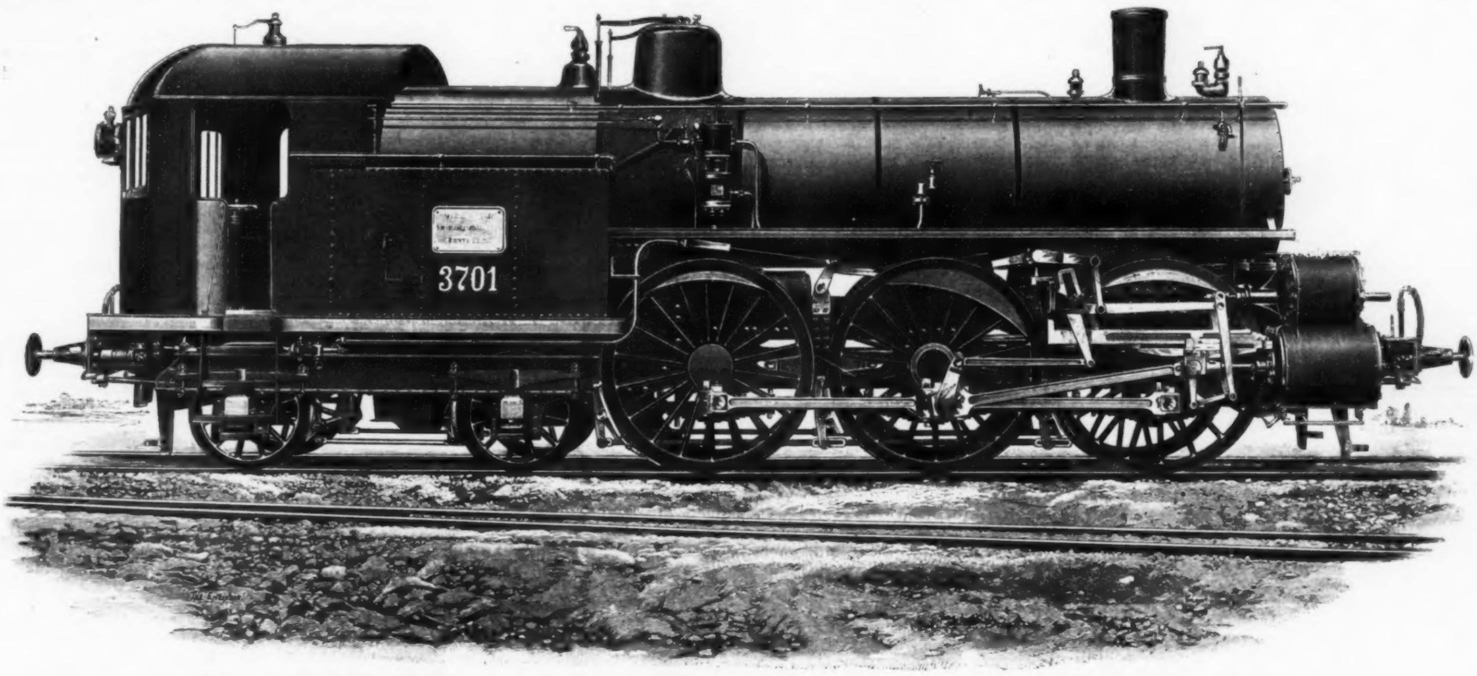
Each front end—inside end—of both sets of cylinders is cast solid, the cover at the opposite ends fitting inside the cylinder. The piston valve chests are fitted to planed seatings on the cylinders, and both their domed covers are separate pieces. The position of the reversing links at the cylinder side of the wide-reaching motion plate—at the end of which a bushed bracket carries the link-pivot bearings—is not unusual in another type of locomotive having wheels coupled near to the cylinders, but the position of the links there has called for the employment of a very massive rocking lever extension upon which each link is securely embedded and bolted.

This extension, to the eccentric crank-rod ends, takes the latter clear of this bracket form of motion plate, and, although the extension lever itself avoids the guide-bar of the crosshead, yet the front end of the guide-bar has had to be forked to allow the link to work through its center line. This arrangement is seen best in the perspective view already given of the smoke-box end.

The high-pressure and low-pressure connecting-rod big-ends outside are solid or box pattern, as also are the coupling-rod ends, but the inside big-ends are forked, and the screwed cotter, as well as the closing block and its bolt, are together at the same end of the brass. The eccentric crank-rod ends connecting with the links are bushed plain eyes. All the connecting-rods are of I section, and the crosshead guide-bars are channeled along the length of the stroke.

The crosshead slide of bronze works between the lower surface of the guide-bar and the upper edge of a truss-bar bolted thereto. The middle slides are merely held down by ⅝-inch plates screwed up beneath the horn-guides.

The next transverse plate, ½ inch thick, is situated in a line with the fulcrum axis of the first equalizing lever, the space between it and the previous transverse being covered in by an apron, ½ inch thick, secured to the side frames with angle irons. Further back the smoke-box saddle forms the next tie. This is a very solid piece of work; the ⅝ inch sides being made up with the transverse plates by means of curved and straight angle irons, 4⅛ inches by 4⅛ by ½ inch thick, riveted with ¾-inch rivets. The sides stand flush with the 1⅜-inch main frames, and are secured to it by the intermediary or 11-16-inch strap plates and 1-inch bolts. The fastening to the smoke-box is by ⅞-inch bolts. All bolts, it may be mentioned, are to English sizes and with Whitworth threads, the company's lathes all being fitted with this standard.



THE PARIS EXHIBITION—EXPRESS COMPOUND LOCOMOTIVE, SOUTHERN RAILWAY OF ITALY.

The total depth from the top of the saddle to the bottom edge of the frame is considerable—5 feet 3¼ inches. The front—always according to the direction of advance—transverse plate has maximum and minimum depths of 3 feet 6⅝ inches and 1 foot 9¼ inches by ¾ inch thick. On it are carried the single guide-bars, inclined with the cylinders at 4 deg. off the horizontal. The front transverse plate is scolloped and varies in depth from 2 feet 7 inches at the sides to 8¾ inches in the center. Behind the saddle the frames are tied in with the cylinder casting, and to accommodate which piece the plates have been cut out low down to very little above the axle line, the depth beneath this being rigidly braced by the arching brackets underneath the cylinders and by the rear buffer beam which follows close up to the casting.

A peculiarity of the framing is that it tapers off at the front end to a width of 3 feet 2 inches, contracting inward from a point immediately in front of the transverse bogie pivot frame, the interval thus made in the width to the ends of the buffer beam being filled by heavy corner brackets. Instead of being fixed upon the tender the guard irons are carried on the rear end of the engine frame as in tank engines.

The bogie frame is an outside one; its sides are of I girder section, and inside at its ends are riveted the L brackets of the spring hangers.

The width of the cradle at its middle, 19⅛ inches, exactly fills the interval between the transverse sides of the caisson, but this width is diminished to 6⅛ inches only at each end, where there are jaws, of a half-round section underneath and 3⅝ inches thick through its center, which drop over and are free to turn upon the bent middle portion of a forging, square in section, the turned ends of which form the swiveling pins in the lower ends of the oscillating levers as indicated in the sectional view of the fire-box.

Thus neither the galloping of the bogie frame on its springs nor the see-saw of side movements can set up any stress between the various fixings to the main frame.

The maximum play allowed to each side between the projecting butters on the bottom ends of the swinging hangers and the lateral sides of the caisson is 2 inches.

In accordance with recent locomotive practice, brake blocks are provided to the bogie wheels, one to each tire, the air cylinder being located, piston forward, in the right side of the bogie frame, and operating a horizontal lever, connected by a central bar to a transverse shaft, which pulls on the front blocks and, by means of fulcrumed side levers, forces back the rear blocks.

The bogie journals are 5½ inches in diameter by 11⅞ inches long. The axle diameter is contracted at the middle. The axle-boxes are cast iron. The coupled axles (steel) are straight with journals 7½ inches by 10⅝ inches, but the rear axle-boxes are narrowed to allow a play of full ⅜ inch on each side of the axle. The steel cranked axle is 7½ inches in diameter, as are the journals also, with a length in the latter of 9½ inches. The crank webs have parallel sides, each outside web standing at right angles, while the inner web is pitched inward at about 96 deg. The crank pins are 7⅞ inches in diameter by 4⅞ inches in length. Outside, the cranks are of iron, case-hardened, the coupling-pin being 5⅞ inches (inside end) diameter by 5¾ inches long, while the big-end pins (outside end) of the high-pressure and low-pressure outside cylinders are 4¾ inches by 4¾ inches, and the eccentric crank-pin at the extremities of the forging is 2⅝ inches diameter by 2¾ inches long. The eccentric cranks are 15⅝ inches long between centers. The axle-boxes are of iron lined with patent metal. The horn guides are steel casting with the screwed cotter keys set to their rear faces by a horizontal screw therein.

All the springs are of the straight-leaved Belgian pattern with nibs on the top leaf, to which a notched washer is held by a nut and lock nut on the hanger.

A sand-box of thin steel in the form of a saddle is placed in front of the fire-box beneath the boiler, and has filling traps on both sides. Sand pipes are laid on before the leading drivers only, and provided with Gresham ejectors. Each coupled wheel is braked with a cast iron block worked either by hand screw or by an air cylinder operating on the same fulcrum lever, and situated in the smoke-box saddle caisson. With a normal pressure of 54½ pounds in the brake pipe the effort exerted on the blocks is almost half that of the locomotive's weight, viz., 55 per cent on the driving and 35 per cent on the bogie wheels.

The Westinghouse brake pump is placed on the left side of the boiler, and takes steam from the dome by a 2-inch pipe. Two air reservoirs are placed between the front coupled wheels. Lubrication of the cylinders, etc., is maintained by Nathan sight-feeds. On the bronze high-pressure piston valve extension guide a grease cup is used, and a special oiler is provided in the cab for the bogie pivot. Two Coale—Baltimore—pop valves, placed on the fire-box shell, and two spring balances on the dome regulate the boiler pressure. Only 2 feet 7¾ inches of the sheet steel chimney stands above the boiler sheathing, the remaining 2 feet 3 inches projecting into the smoke-box, where its length is added to by a petticoat pipe 1 foot deep and 2 feet 5⅝ inches diameter at its mouth, which is 3⅝ inches below the level of the top tubes. A deflector plate covers the domed smoke-box door. The cab is a well-lighted, airy place, with polished pitch pine match boarding inside the roof; the windows in the rear are of square shape; a frosted bulb covers the oil lamp; the gage glasses are screened with large half-circular hinged glasses, themselves protected with wire mesh; the two sliding doors of the half-round fire-hole are opened simultaneously by a touch on a vertical lever.

In the smoke-box all the pipes are of copper. Both pistons of each piston valve are of steel cast in one piece, with a hollow core in the middle surrounding the piston-rod, by which they are traversed.

There being only two piston valves, the reversing screw is the usual arrangement as for simple engines, but placed vertically in the right-hand side of the bay front. It has a double thread, two to the inch, 1⅝ inches at the bottom and 2 inches diameter at the top of the thread, and worked in a vertical floor bracket by a perforated bronze hand wheel, having a small hand key in its center engaging in any one of the eight keyways cut in a small disk underneath and rigid with the screw. Its movements are recorded on a cylindrical vertical scale placed in front of the driver's eyes, the pointer being actuated from an extension on the forked crank worked by the vertical screw. The distance from the screw forward to the weigh-bar is traversed by two long bars, one from the screw transverse shaft to a lever pivoted by a steel bracket to the frame in front of the right-hand leading driver, and 15 feet 2¾ inches long, and the second from this lever forward to the curved weigh-bar shaft. These bars are of square section, the first 1¼ inches by 3½ inches at its middle length, while in the second the metal is ⅛ inch thicker.

The cylindrical tank of 3-16-inch steel plates is carried by I section frames on six wheels, each braked by two blocks and worked by a tender air cylinder. A brakeman's box, completely closed in, is erected on the rear of the frame.

A very sober finish is given to the locomotive by a finely-surfaced black paint resembling brilliant stoved enamel, and employed throughout on every part of the engine and its tank without a single stripe of relief color or a polished band or beading save the plate glass window frames, the name-plate, number, etc.—of bronze—the small bronze boiler mountings, the beautifully-finished working parts and the polished equalizing levers—conveying an impression in harmony with the size of the engine.

The plates of the boiler barrel and fire-box shell are of steel, their thickness being ⅜ inch for the smoke box, a little under 11-16 inch for the first and second boiler rings, a little above 11-16 inch for the coned ring, and 13-16 inch for the roof sheet of the fire-box shell, while ⅝ inch is employed for the spreading side sheets. The foundation and fire-hole rings are of iron, the latter having the lower half of its opening protected by a cast iron beading, the lip of which covers the lower rivet heads of the ring. The longitudinal seams of the boiler are butted, and double-cover strapped, the outer narrow strap being full 9-16 inch thick, and double zig-zag riveted, while the thinner inside strap, of greater width, has an additional chain row of rivets uncovered by the top strap.

The cylindrical steam dome, 2 feet 3⅝ inches diameter, is formed of ½-inch steel with a double riveted lap joint, its flanged base, ¾ inch thick, being secured to the conical boiler ring with a single row of ⅞-inch rivets. The boiler at this part is particularly strong, the rivets passing through, first, a reinforcing ring 11-16 inch thick, elongated by two ears to cover the entire length of the boiler ring, and then, after the thickness of the boiler, through a strap-plate 1 inch thick, of elliptical form, extending beyond the surface limits of the top ring, the whole being secured together by a double row of rivets. These plates are so arranged that all come inside of the set-out edge of the fire-box shell, the ears of the reinforcing plate there being thinned off from a thickness of ¼ inch to a feather edge, and then included in the double-riveted transverse seam. But back to the middle ring of the boiler all these plates come outside, the inside strap in this case being similarly thinned by forging, and fitted above the set-in edge of the preceding barrel ring. An angle-iron ring, or manhole, 1 3-16 inches thick at the top of the dome ring, forms the seating for the flat dome cover. A bracket ¾ inch thick for the support of the steam column is fixed by four ¾-inch rivets to the back of the dome ring.

In the boiler exceptionally strong staying has been adopted. The 1 inch steel tube plate is riveted, flange outward, 2¾ inches back from the boiler end, and stiffened with a girder stay cut out from ⅝ inch plate iron, having a depth of 19 inches at its sides, and secured by means of 2¾-inch angle irons against the tube plate with a row of nine ⅞-inch rivets, the ends of the stay being similarly attached by five rivets to the barrel ring. On each side of the steam pipe hole in the tube plate are riveted gusset stays of the same depth of 19 inches, the two ends of each being fixed in the same manner as with the girder stay. The hole itself is stiffened by a thick ring outside, taking the flange of the steam pipe.

At the fire-hole sheet of the shell the boiler staying is similar. Here are two transverse girder stays, scolloped, in ⅝-inch iron, and having a maximum depth at the sides of 20½ inches for the top stay and 24 inches for the lower one. These are riveted to the fire-hole sheet, sandwiched between two angle irons, the upper one of which has in each case treble the strength of the lower one. The minimum height of each girder from the fire-box is 11⅞ inches and 4 inches, respectively, the ends being secured to the curved sides of the roof by means of forgings with webbed ends 13 inches by 6 inches for the upper, and 16½ inches by 6 inches for the lower, and fixed by seven bolts for the first, and nine bolts for the second, these bolts being riveted over in the lower sides of the feet where the metal is thinnest.

This engine has been designed with the intention of avoiding as much as possible all oblique strains, to have all its bearing surfaces as large as permissible, and in every way to sacrifice an apparent for an effective simplicity by placing every moving part where easily accessible and in view.

It will be put into service after the Exposition on the different sections of Milan-Venice, Milan-Bologna, Bologna-Porretta, and Florence-Rome stretches, on which the maximum gradients and minimum curve radii are respectively as follows: For the first, gradients of 1 in 100, with curves of 1,300 feet; for the second, gradients of 1 in 200; for the third, gradients of 1 in 77, and curves of 970 feet; and, for the last-named gradients of 1 in 83, with curves of 1,130 feet. The distances to be run are very short, the maximum of them being that from Orte to Rome, a little over 50 miles.

The coal to be used is, as before mentioned, Cardiff, in lumps and in the form of briquettes, with a calorie power of 7,000 to 7,700.

A PROMINENT English engineer, Mr. A. J. Barry, who has recently returned to London from Siberia and China, expresses a poor opinion of the work upon the Trans-Siberian Railway. In a published interview he declares that in the construction of the Trans-Baikal section the sole objects of the Russian engineers appear to have been cheapness and rapidity. He declares that the single line of rails starting from Lake Baikal eastward is so badly laid that it can accommodate neither fast nor heavy traffic. It is a series of sharp curves and steep gradients. A rise of one in sixty is frequent; and even if the line were a good one, the steep gradients and sharp curves would prevent anything like a fast service of good trains. Even while the line remains in good order, its carrying capacity is strictly limited. But it will not long remain in good working order, he says. It will want continual repairing. The line has been laid with 48-pound rails, and that alone will prevent heavy traffic from running over it. In India 75-pound rails have been found too light, and are being replaced by heavier. When the rails are light, heavy sleepers are absolutely essential, but in the Trans-Baikal road both the sleepers and the ballasting are of the most inferior kind. Where banks have been constructed the work has been confined within the narrowest possible limits, and Mr. Barry expects to see much of it washed away in heavy storms.

THE GEOLOGICAL SOCIETY OF AMERICA.

THIRTEENTH ANNUAL MEETING, ALBANY, DECEMBER 27-29, 1900.

By EDMUND O. HOVEY.

ABSTRACTS of some of the more important and popular of the papers read at the thirteenth annual meeting of the Geological Society of America, which was held in Albany, N. Y., December 27-29, 1900, are given here. Scant justice can be rendered these valuable contributions to the science, and interested readers are referred for full details to the articles themselves as they come out in The Bulletin of the Society.

ON THE GEOLOGICAL RECORD OF THE ROCKY MOUNTAIN REGION IN CANADA, by George M. Dawson. Presidential address.—Twenty years ago, after six seasons of work in British Columbia or on its borders, the author read a paper before the Geological Section of the British Association for the Advancement of Science, at Swansea, entitled "Sketch of the Geology of British Columbia," which was afterward published in The Geological Magazine. So far as they go, the general outlines then laid down still hold; but much has been accomplished since that time, the relative importance of the observations recorded has been considerably changed, and opinions stated from time to time have had to be modified as the work progressed.

The region dealt with is in many respects one of particular geological interest, but its older rocks are separated from those of the eastern parts of Canada by the whole width of the Great Plains and the newer formations found in it are generally unrepresented in other parts of Canada. Nor until the work was well advanced, did any satisfactory standard of comparison exist in the Far West. California could be referred to in regard to certain defined formations of the Tertiary and Cretaceous, but a great intervening region of the Cordillera remained practically unknown geologically, except for the earlier results of the Hayden surveys and some reconnaissance surveys by other explorers along lines of travel. It was in this region also that the occurrence of contemporaneous volcanic materials as important constituents of the Mesozoic and Palæozoic rocks of the Cordilleran belt was first recognized. Previous to the earlier reports of the Canadian Geological Survey, the existence of such volcanic materials had been admitted only as regards the Tertiary formations of the western portion of the continent.

As compared with the Cordilleran region of the western United States, that of British Columbia is much less diffuse and more strictly parallel with the corresponding part of the Pacific coast. Its length is approximately the same, but its width is usually only about 400 miles. The geological features follow the main physical features, the rock series represented differing much in age and composition within comparatively short distances as the Cordilleran belt is crossed, while they run far and with closely accordant characters in the direction of its length. This depends upon two conditions, both of which have been imposed by the position of the zone of recurrent crustal movements coincident with the western border of the continent—(1) the occurrence of successive zones of deposition, whether sedimentary or volcanic, parallel to the continental edge; (2) the actual compression of the original area of deposition by folding and fracture produced by pressure from the Pacific side, by means of which the superfices may have been reduced to about one-third of its original width since early Palæozoic times.

The ruling orographic features of the Cordilleran region in Canada at the present time are the Rocky Mountains proper, forming its high eastern border, and the Coast Ranges of British Columbia on the west. It has been proposed by Dana to name the first of these ranges the "Laramide Range," since its origin was coeval with the close of the Laramic period. This mountain system seems to begin about the 46th or 47th parallel of north latitude, from which it runs in a northerly direction to the Arctic Ocean. Its width is about sixty miles, and the height of many of its peaks exceeds 11,000 feet. The rocks composing it are for the most part referable to the Palæozoic series, and it is found to be affected by numerous great faults parallel to its direction and overthrust to the eastward. The Coast Ranges of British Columbia form a belt of about 100 miles in width that extends along the border of the Pacific for at least 900 miles, beginning near the estuary of the Fraser and eventually running inland beyond the head of Lynn Canal, where the coast changes its trend to the westward. These ranges are composed chiefly of granitic rocks, with minor included masses of sedimentary strata. The belt is later in date of origin than the Cretaceous period, but is neither so lofty nor so ragged as the Laramide Range. The remarkable fiords of the Pacific coast, both those of British Columbia and those of the southern part of Alaska, are the submerged valleys of this coastal system of mountains, their erosion being probably referable to Eocene and Pliocene times, during which the land stood at a relatively high level.

To the west of the Laramide Range and separated from it by a remarkably long and direct structural valley, is a somewhat irregular and sometimes interrupted series of mountain systems to which the general name of the Gold Ranges has been applied. This embraces the Purcell, Selkirk, Columbia and Cariboo Mountains, all including very ancient rocks and evidently representing the oldest known axis of elevation in the province, although it has not remained unaffected by movements of a much later date. Peaks surpassing 10,000 feet in elevation still occur in these mountains. Between the Gold and Coast ranges, with a width of about 100 miles, is the interior plateau of British Columbia, a peneplain referable to the early Tertiary, which has subsequently been greatly modified by volcanic accumulations of the Miocene and has been dissected by river erosion at a later date. This plateau country is well defined for a length of about 500 miles, sloping northward from a height of more than 4,000 feet near the 49th parallel to one of less than 3,000, and with an average elevation of about 3,500 feet. It is then interrupted for some four degrees of latitude by a mountainous country chiefly composed of disturbed Cretaceous rocks, beyond which the surface again declines to the plateau lands of the Upper Yukon basin with its separated mountain ranges. The interior plateau is throughout very complex in its geological structure, but except where covered by Tertiary accumulations, it has been found to be chiefly underlain by Palæozoic and Mesozoic rocks.

One more mountain system remains to be noted. This stands upon the real border of the continental plateau and is represented by the long, ridge-like highlands of Vancouver Island and the Queen Charlotte Islands. It is apparently wanting between these islands and is not clearly continued in the archipelago of Southern Alaska, which seems to be more closely connected with the Coast Ranges of mainland. The formations chiefly comprised in this outer mountain system range in age from the Carboniferous to the Cretaceous.

The following table shows at a glance the relations of the beds in the two great geosynclines and their thickness:

Geological Age	Western Geosyncline.	Feet.	Laramide Geosyncline.	Feet.
Pliocene.....	Horsefly gravels			
	Quartz drift of Klondike, etc.......	......	....	......
Miocene	Upper volcanic group.	3,100	....	..
	Tranquill beds........	1,000	....	......
	Lower volcanic group.	5,300	....	......
Oligocene...	Coldwater group (Similkameen beds, etc.)...............	5,000	....	......
Eocene	Puget group (on coast only)	3,000	Upper Laramie..	3,000
			Lower Laramie..	2,500
Cretaceous...	Nanaimo group.... ..	2,700	Montana, Colorado, ...	3,140
	Queen Charlotte Islands group (in Queen Charlotte Islands)...	9,500	Dakota, Kootanie, ...	9,750
Triassic......	Nicola group.....	13,500	(Red beds to S., Marine to N.), say ..	600
Carboniferous.	Cache Creek group.....	9,500	Banff series......	5,100
Devonian	(?)........	......	Intermediate limit.	1,500
Silurian..	(?).........	.....	Halysites beds.....	1,300
Ordovician...	(?)......	......	Graptolithic shales.	1,500
			Castle Mt. group, (upper part),	
Cambrian....	Adams Lake series......	25,000	Castle Mt. group, (lower part),	8,000
	Nisconlith	15,000	Bow River series..	10,000
		89,600		46,390
Archæan,.....	Shuswap series.......	5,000	....	....

The memoir then goes on to discuss with great wealth of detail the characteristics of each of the geological systems represented in the vast region under consideration, concluding with an abstract of the physical history of the area. The recurrence of folding and disturbance parallel to the border of the Pacific Ocean basin and the concurrent great changes in the elevation of the land with reference to the sea continued down to quite recent geological times, the latter even into the Pleistocene. It is evident that there was great energy of denudation. This was in part due to the events just referred to, but it was also dependent upon the position of the region on the eastern border of a great ocean, where in northern latitudes, an excessive rainfall must have occurred at all periods on the westernmost mountain ranges. It is not probable that any comparable denuding forces have been exercised on the eastern side of the continent since the definition of the Pacific and Atlantic Ocean basins.

Prof. Frank D. Adams' paper on "Experimental Work on the Flow of Rocks Recently Carried Out at McGill University" was a continuation of one on the same subject which was read before the Society three years ago and which has been published in part, with illustrations, in the SCIENTIFIC AMERICAN. It aroused much interest and discussion. Very diverse views have been expressed in explanation of the movement of rocks in the earth's crust. All investigators agree, however, that there are three factors to be taken into consideration: pressure, heat and percolating waters. The experiments described were undertaken to determine, if possible, the effect of each factor alone and in combination with one or both of the others. Carrara marble was chosen as the subject of experimentation on account of its homogeneity and softness. Collars of wrought iron were used which had been built up like ordnance, in order to simulate in some degree the strata comprising the earth's crust. A bar of iron was wound with strips of Low Moor iron until the desired thickness was attained and the whole was welded together, after which the bar was bored out. Cylinders of marble about one inch in diameter and one and one-fourth inches long were used in the experiments, the iron collars being shrunk upon them to insure the closest possible contact. The pressure was applied by means of a hydraulic press, capable of exerting 95 tons pressure to the square inch easily. Furthermore, increase of pressure could be effected with whatever degree of rapidity might be desired. In the first series of experiments the cylinders were subjected to pressures up to about 45 tons to the square inch, at which point the iron collars usually began to show signs of rupture, and the temperature was that of the laboratory. The original crushing strength of the marble was about 13,000 pounds to the square inch, but the compressed columns were weaker than the original material. Rapidly deformed columns were found to be weaker than those treated more slowly. A cylinder with which the maximum deformation was reached in ten minutes showed a crushing strength of but 2,000 pounds to the square inch after removal from the collar, while one which had been 64 days in reaching that stage had a resistance of 5,000 pounds. In the new series of experiments with heat as well as pressure after 124 days at 300 degrees C. the strength of the marble was nearly equal to the original, while at 400 degrees C. the strength was still more nearly equal thereto. Pressures of 30, 40 and 50 tons to the square inch were used. When moisture was added to the heat and pressure, it was found, after 54 days' treatment, that in one instance the strength was 50 pounds to the square inch greater than in the original, while in other cases there had been at least no loss. Microscopic thin sections of the deformed cylinders showed that under cold, dry pressure cataclastic (crushed) structure was developed in the rock, that under hot dry pressure no cataclastic structure appeared, but many twinning planes were developed and there was some gliding of portions of the grains over one another, while under hot, moist pressure there was added to the last features evident flowage of the material. At high temperatures, therefore, marble may be said to flow as truly as metals under compression. A beginning has been made on the comparison of the thin sections from these deformed columns with limestones from regions of great metamorphism. Forty-two such limestones were examined, fifteen of which showed features which had been observed in the deformed columns.

Another paper which aroused much discussion was that by Marius R. Campbell, entitled "An Hypothesis to Account for the Extra-Glacial, Abandoned Valleys of the Ohio Basin," in the course of which the author said in part: The lower courses of the Allegheny, Monongahela, Kanawha, Guyandot, Big Sandy and Kentucky Rivers are characterized by abandoned channels which generally range from 100 to 200 feet above the present streams. For the most part these channels are deeply covered with silt, but sometimes the rock floor is only partly obscured by a thin layer of sand and gravel. The streams which have forsaken these valleys have sought new routes along which they have carved deep channels through the upland topography. Teay Valley in West Virginia is perhaps the most noted example, but the old channels at Carmichael and Masontown on the Monongahela River, and at Parker on the Allegheny are also well known. No reason has been assigned for the abandonment of these channels; they cannot be considered as "oxbows," and they are all beyond the limit of the glacial ice-sheet. The author presents the hypothesis that they were due to the breaking up of river ice and the formation of local ice dams, which were of sufficient height to force the water over the lowest divide in the rim of the basin, and which persisted long enough for the stream to intrench itself in its new position. It was evident from the discussion following Mr. Campbell's paper that his co-workers in glacial geology would not accept the substitution of local ice dams for a general one in explanation of high-level terraces without further investigation.

The glacial lakes of Minnesota were discussed in detail by N. H. Winchell, whose paper called attention to lakes already located and mapped by Warren Upham and others. There were two principal ice lakes; the northwestern, which occupied the valley of the Red River of the North, and of the Minnesota, and the northeastern, which had its gathering place and momentum in the valley of Lake Superior and the westward. At various places the drainage lines of the State as they now exist were disturbed by the ice margin, forming lakes which sought outlets by higher passages to the Mississippi than those now occupied by waters which pass through the same valleys. These lakes, the waters of some of which would have entered Lake Superior, had their direct lines of descent not been obstructed by the glacier, were by it diverted to the Mississippi. There were twenty-six of these lakes indicated on the map accompanying the paper. Two other papers on Pleistocene geology were presented to the society, the first of which was by A. P. Coleman, on "Marine and Fresh Water Beaches in Ontario," and the other by F. B. Taylor, on the "Glaciation of Michigan and Ontario." The principal point of the latter paper was the identification of the bed of a great glacial stream which ran along the side of the moraine near Guelph and Galt, Ontario. This river bed is 200 or 300 feet higher than the bottom of the valley, and has been heretofore described as a raised beach.

The question of the proper location of the boundary to be established between the Silurian and the Devonian systems in this country is one which is arousing much interest and receiving much careful study from the palæontologists and stratigraphical geologists at the present time. Careful attention therefore was paid to the paper by H. M. Ami, on the Knoydart formation in Nova Scotia, which the author described as being a bit of "the Old Red Sandstone" of Great Britain. The most important part of Mr. Ami's paper, perhaps, was the naming of five newly differentiated and named geological formations, which occur at Arisaig, Nova Scotia. The "Knoydart" formation consists of red shales and sandstones and calcareous bands holding pteraspidian and ostracoderm fishes and crustaceans referable to the Cornstone or lower Old Red sandstone of Great Britain. The Knoydart beds immediately overlie the Silurian strata, though no actual contact has been observed. The Silurian series at Arisaig consists of at least four distinct geological formations. Beginning above we have first the "Stonehouse" formation, consisting for the most part of dark red, fine grained shales and sandstones, holding a conspicuous lamellibranchiate fauna, of which Grammysia Acadica Billings is a well-known species, together with a number of inter-stratified more or less thin calcareous bands holding brachiopods, gastropods, trilobites and ostracodes in abundance. Below this comes the "Moydart" formation, which consists of more or less heavy-bedded, light greenish gray and rusty-weathering calcareous strata (in which the "Red Stratum" of authors occurs) and holds brachiopods, gastropods, cephalopods and crinoids. Beneath this again we have the "McAdam" formation, consisting for the most part of impure black carbonaceous shales, which are splintery at times, holding a lamellibranchiate fauna, graptolites, etc. At the base comes the "Arisaig" formation, which comprises buff-weathering, fine-grained compact sandstones and shales, containing corals (chiefly Streptelasma), brachiopods, gastropods and trilobites. The thorough investigation of this series of strata, which indeed, may require further subdivision, is expected to furnish the data for the satisfactory settlement of the mooted question as to where the Silurian stops and the Devonian begins in America.

An article contributed by Charles R. Keyes, on "A Depositional Measure of Unconformity," discussed the great unconformity at the base of the coal measures in the Upper Mississippi Valley and brought out some new considerations as to its importance. The author showed that the coal measures of the western interior basin find greater development than those of any other locality known in America, no less than three great series being recognizable, each of which is as important as the combined series as usually developed in Pennsylvania. The lower coal measures of the Upper Mississippi Valley, though resting in great part directly on lower carboniferous beds, are in reality in the upper half of the carboniferous series. The hiatus at the base of the coal measures in the Upper Mississippi Valley has in the south a depositional equivalent, the importance of which is greater than the whole of the coal measures to the north. The Ozark uplift had no effect in determining the deposition of the coal measures, because it did not take place until long after the close of the period. Twenty thousand feet of the Arkansas coal measures are found to have been deposited during the period represented by the great stratigraphic break in the north.

The title of one of the papers by W. M. Davis was "An Excursion to the Colorado Canyon." The substance of the paper was that observations made in the canyon of the Colorado and over the plateaus on the north and the south during a three-week trip in June, 1900, added the occurrence of certain landslides and migrating divides to the evidence already stated by C. E. Dutton in favor of two cycles of erosion in the development of the Grand Canyon district; the broad denudation of the plateaus having been accomplished in the first cycle, and the incision of the narrow canyons in the second. The faults by which the plateaus are intersected are regarded as for the most part of greater antiquity than the canyon cycle. The author questioned the correctness of the theory that the drainage of the region had been altogether determined before the elevation of the plateau. The high level floor of the Toroweap Valley is explained by change of drainage (stream-robbing) rather than by the failure of its former water supply through a change from a humid to an arid climate. The author does not consider that the Grand Canyon district in itself necessarily indicates that the ancient climate was more moist than the present. In another paper Prof. Davis discussed the fact that in making a section across a series of river terraces in any of the valleys of New England, it is usually the case that the low level terraces are found to be separated by a shorter distance than the high level terraces, and he proposed to explain the phenomenon in certain cases by the occurrence of rock ledges which interrupt and control the lateral swinging of the river as it cuts its way downward.

George B. Shattuck showed how apparent unconformities may occur during periods of continuous sedimentation. He has recently been studying the bluish green clays which lie in hollows in rocks or beds of Eocene, Miocene and Pliocene age at various places in the Middle Atlantic States, especially in the vicinity of Chesapeake Bay. He considers that they are lagoon deposits, and that they were formed by the waves throwing bars across the mouths of old valleys and forming ponds, which became swamps filled with clay, marls and so on. They were finally covered by the migration of the bar landward, so that the unconformity between the clay and the contemporaneous overlying deposits is due to the manner of deposition.

The great tuff cone forming Diamond Head near Honolulu, in the Sandwich Islands, was the subject of a paper by C. H. Hitchcock. The cone is 762 feet in height, and shows a crater a little to the east of its center. Some observers have considered that the base of the cone consists of limestone, and that the whole is of submarine origin, but the present author contends for the sub-aerial character of the deposits, holding that the cone was erupted through beds of coral limestone, masses of which were torn off and thrown out with the other materials of the cone, and that these loose blocks are what were taken by some others to be strata in place.

The geology of Rigaud Mountain, Province of Quebec, Canada, was treated at length by O. E. Leroy. The chief topographic feature of the Palæozoic plain of Central Canada is a series of hills occurring in the district about Montreal. These hills are of igneous origin and follow a line of disturbance which is almost at right angles to the trend of the Notre Dame Mountains. Rigaud is the most western of the series and consists of an area of hornblende syenite, which is pierced on its northern flank by a quartz syenite porphyry. The field relations of all the hills with the exception of Rigaud show them to be of post-Silurian age, in the case of the latter, the contact with the Palæozoic is fully concealed by drift. The object of the research was to ascertain whether a genetic connection could be established between Rigaud and the other hills to the east. Investigation shows that such a connection probably does not exist.

The discovery of great quantities of crystalline limestones in Baffin Land was announced by Robert Bell in 1897, since which time the region has been somewhat more fully studied. Mr. Bell described the geographical position and physical aspect of the region and went into considerable detail as to its geological character. The rocks of the north side of Hudson Strait are Newer or Upper Laurentian, and consist usually of a gray gneiss the strike of which is generally parallel to the coast line, which trends northwest. On the south side of the strait there is no general direction to the strike of the rock, and there are at least twelve distinct bands of white, red and salmon-colored limestones interbedded with gneiss. The limestone is coarsely granular and sometimes contains a considerable percentage of feldspar. The region was explored for about 150 miles and the bands of limestone were found to be very persistent. The total thickness of the bands is not less than 30,000 feet, so that the conditions under which they were formed must have been continuous for a long time. The limestone must have been deposited by sedimentation in a deep ocean and not by segregation from the very small relative amount of gneissoid materials.

In presenting a paper on the "Origin and Age of an Adirondack Augite-Syenite," H. P. Cushing stated that recent work in the field, together with chemical analyses demonstrates that the Adirondack anorthosite shows a certain amount of differentiation and passes locally into an augite-syenite, all intermediate phases being found, as was contended by the author in a paper read before the society two years ago. There is much evidence now at hand to show that a large part of the great body of the augite-syenite gneiss in the Adirondacks is older and is to be referred in age to the main body of the gneiss of the region, whatever that may be.

Some of the phases of the Klamath Mountain region of Northwestern California and Southwestern Oregon were treated of by J. S. Diller. He said in substance that during Neocene-Tertiary time this region was reduced by long continued erosion to a peneplain, and that the resulting marine sediments rich in fossils deposited along the ocean border recorded its age. The Neocene strata were compressed and tilted and with the Klamath peneplain and monadnocks were uplifted somewhat differentially several hundred feet above their former level. The invigorated streams in the rather long succeeding epoch of stability cut wide valleys across the peneplain to the coast, where extensive wave-cut terraces were developed. A much greater differential uplift followed, the altitude for the Klamath peneplain near the coast becoming 1,200 to 2,000 feet; while near the crest of the range 7,000 feet was attained. This caused the streams to cut deep canyons before the close of the glacial period. Near the northern border of the Klamath Mountains on the coast there has been a recent subsidence, converting the lower courses of the rivers into tidal inlets.

The mountain ranges of the Great Basin region have been recently re-studied by J. E. Spurr, and he presented an elaborate paper on their origin and structure. Most of the studied ranges were described in detail, and deductions made as to the relative importance of erosion and direct deformation, either by faults or folds, in determining the present topographical relief. The author arrives at the conclusion that the ranges in general owe their existence to long continued erosion or rocks folded and faulted by many successive movements, and that it is only exceptionally that the folds or faults are expressed in deformation of the present surface.

The other papers which were read in whole or in part were, on the Alleged Parker Channel, by E. H. Williams, Jr.; The Palæozoic Limestones of the Kittatinny Valley, N. J., by H. B. Kummel and S. Weller; on Some Fossiliferous Layers of the Calciferous Beds in Dutchess County, N. Y., by W. B. Dwight; The Niagara Group Along the Western Side of the Cincinnati Anticline, by A. F. Foerste; The Use of Stereographic Projection in Map Construction, by S. L. Penfield; The Weathering of the Granite Rocks of Georgia, by T. L. Watson; The Peneplain of Brittany, by W. M. Davis, and On the Development of Biserial Arms in Certain Crinoids, by A. W. Grabau.

THE POLAR BEAR.

Of the family of bears, the largest, strongest, and most powerful, and, with the exception of the grizzly, the most ferocious, is the polar bear. The distinguishing characteristics of the animal are the great length of its body as compared with its height, the length of the neck; the smallness of the ears; the large size of the soles of the feet; the fineness and length of the hair; the straightness of the line of the forehead and the nose; the narrowness of the head, and the expansive muzzle. The color of the polar bear is invariably a dingy white. The size varies considerably. Sometimes a polar will attain a length of more than eight and one-half feet.

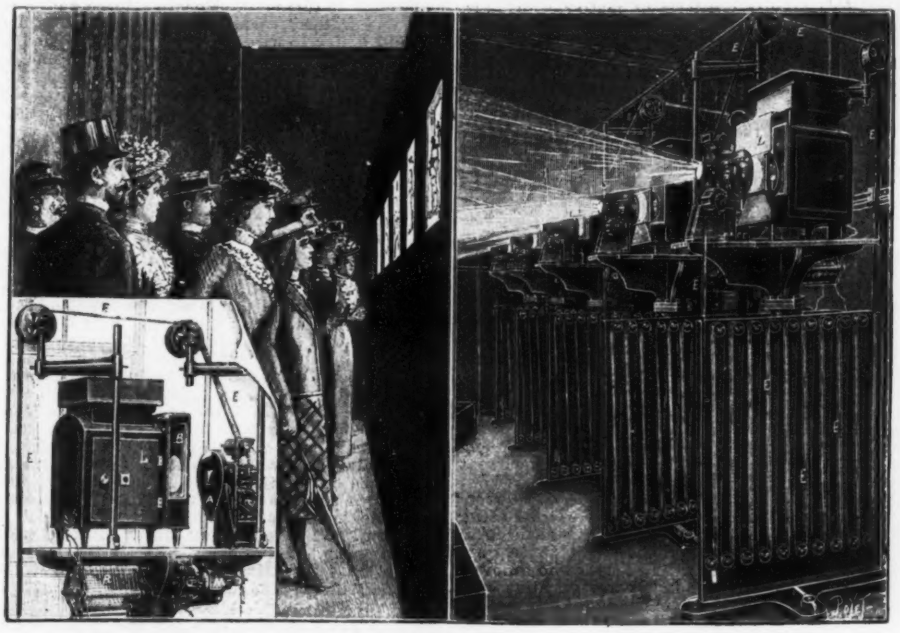
The domestic habits of these powerful animals are but little understood. Whether they hibernate or not has not been definitely ascertained, although it is believed that the male at least is not dormant so long as the land bears of the North. Dr. Kane in his work, doubts whether either sex actually hibernates; she-bears with their cubs visited his winter quarters during the midnight darkness. Other writers state that the female alone hibernates. The pairing season is said to be in July and August; and the attachment of the pair is such that if one is killed, the other remains fondling the dead body, even suffering itself to be killed rather than to leave it. The same wonderful affection of the female for her cubs has also been noticed.

The habits of the polar bear are purely maritime. Although the system of dentition is the same as that of the other bears, the food is of necessity wholly animal.

POLAR BEARS NEAR SPITZBERGEN.

AN AUSTRALIAN COAL MOUNTAIN.

THIRTY-FIVE miles from Sydney is a picturesquely-situated township whose history is closely identified with that of the coal-mining industry of New South Wales, says The Practical Engineer. So far back as 1796, Flinders and Bass, during their adventurous work of coastal exploration, had seen under the high land and cliffs on which the township of Clifton is situated, a number of black lumps, which they took to be pieces of slate, lying on the ground. Not suspecting the real character of the lumps, they gave but little attention to them. About the same time Mr. Clarke, who, with a number of others, had been wrecked on Cape Howe and thrown ashore by a violent storm, finding himself in an unknown region, and threatened with attack by hostile natives, undertook, with a portion of the party, to proceed on foot along the coast to Sydney, a distance of 300 miles, and obtain assistance for those left behind. It was a most difficult and dangerous journey. Several perished from exhaustion, others were killed by the blacks, and only a few of the party reached Sydney. They were terribly emaciated, and seemed mere skeletons, their food supplies having given out at an early stage of the disastrous journey. Mr. Clarke reported that two days before he reached Watta Mowlee (now called Wattamolia), and forming portion of the coast line of the New South Wales National Park, he discovered some pieces of coal, which he and his companions collected and were thus enabled to enjoy a good fire. In consequence of what Mr. Clarke had stated, Mr. Bass was dispatched in a whaleboat from Port Jackson to ascertain where the mineral was to be found. After he had proceeded a considerable distance beyond Cape Solander he arrived at a steep cliff, in the face of which, washed by the sea, he found—as related in Collin's "Account of the English Colony of New South Wales"—"A stratum of coal, in breadth about 6 feet, and extending eight or nine miles toward the south. Both upon the summit of the high land and lying on the surface at the base he observed many patches of coal which were brought in by Mr. Bass, the quality appeared to be good. But it was thought, from its almost inaccessible situation, that no great advantage could ever be derived from it." The place thus described was Coal Cliff, or, as it is now designated, Clifton. In later years Bulli and Wollongong became available for the shipment of coal obtained from Clifton, but in the meantime Newcastle, the site of which had been discovered in 1798, had secured what was practically a monopoly of the coal export trade. From the sea, the coal seams in the cliff have the appearance of black bands. Curiously enough, the natives do not appear to have become acquainted with the use of coal, their fires being made with leaves and sticks. The summit of the cliff is reached by a somewhat rough zig-zag route, but the journey is amply repaid by the beauty of the surroundings. "The varied foliage," we are told, "is most entrancing, and the transformation from one scene to another makes it a perfect paradise. There are sparkling cascades, bowers of ease bedecked with blossoms, and now and then a glimpse is caught of distant landscapes through the rifts in the foliage. When the top is reached after an hour's climbing the scene is one of enchantment." The village is seen cozily nestling below, while a magnificent panorama of ocean and sky bursts upon the view. It is like entering into a new world—a region of mingled beauty and sublimity. Clifton is situated on the top of a veritable mountain of coal, and were its carboniferous treasure more readily accessible it would share with auriferous Mount Morgan and argentiferous Broken Hill the credit of being among the richest mineral mountains known. The coal is at present obtained from a seam; the broad black band, familiar to all voyaging along the southern coast, is about 6 feet thick, and runs along the cliff about 20 feet from its base. The seam is worked from two adits, the coal being conveyed from the mine to the ship by means of a timber jetty 500 feet in length, said to be one of the boldest and most remarkable undertakings for working a mine known in any part of the world.



THE CINEMATOGRAPH AT THE SECTION OF INSTRUCTION OF THE CITY OF PARIS.

THE CINEMATOGRAPH AT THE EXPOSITION OF INSTRUCTION.

As a general thing, the crowd at the Exposition neglects the sections of instruction, since they do not interest it. And yet there would be an excellent opportunity here for it to get an idea of the effort that we have been making during the last twenty years for the development of public instruction, to compare the methods employed in different countries, and to see that, although our neighbors learned the importance of the schoolmaster before we did, we are now on a par with them as regards the results obtained. But the halls in which all this may be read at a glance remain deserted, their aspect is not very attractive, and the public pays no attention to the pictures hanging on the walls. All, however, do not deal with statistics, for some of them represent interesting phases of school life that are worthy of attracting a little more attention. People pass by these pictures in indifference, as accurate as they are, because they give but an instant of school life, which nevertheless is all excitement. The pictures are not living ones, and coldly represent a phase of acts that are interesting only in so far as they are completely unfolded in a perfect continuity—such, for example, as the entrance and exit of classes with order and method, elementary gymnastic motions, manual labor, etc. In the pavilion of the city of Paris, M. Bedorez, superintendent of primary instruction at the Prefecture of the Seine, has desired to render the section of interest, so as to attract the public thereto, and has perfectly succeeded by having apparatus installed for the production of animate pictures through projection. For a study of the subject he consulted M. G. Demeny, whose labors in chronophotography are familiar to every one, and who is a recognized authority in everything that concerns physical culture. The problem was not of the easiest character to solve, because it was necessary to be content with slight space and little light and to operate automatically in a continuous manner; but, M. Demeny, aided by M. Gaumart, the manufacturer of his apparatus, succeeded in overcoming all difficulties.

As we have already described the Demeny chronophotographic apparatus, we shall not revert to it, but shall merely recall the fact that, for a continuous projection, it presents the great advantage that there is in it no abrupt intermittent motion in the passage of the band. Since this latter forms an endless belt, it is capable of moving for an indefinite length of time without any deterioration. The arrangement adapted is the same as that found in Edison's first kinetoscope. The band of film, which has a total length of 65.5 feet, runs over a series of pulleys placed alongside of each other at the top and bottom of a vertical frame, reaches the upper part of the apparatus and passes between the objective and the source of light. This latter consists of a 100-candle power incandescent lamp. The arc lamp with naked flame had to be rejected as being capable of offering a certain amount of fire risk, especially in connection with an apparatus that is designed to operate without surveillance. The projection is received upon a plate of ground glass of 12 by 16 inches. It lasts for 45 seconds, and then immediately begins again. The band is actuated as in the ordinary apparatus, but for the winch there is substituted a small electric motor. M. Gaumart, however, devised a type of apparatus with an electric motor for large projections some time ago. This permits of causing a series of from 8 to 10 bands, glued end to end and wound upon a single drum, to pass without interruption.

In the installation under consideration there are six apparatus placed side by side in the gallery of the first story of the pavilion of the city of Paris. They are inclosed in an iron plate cabinet, and an aisle between the latter and the wall allows the public to pass into the darkness in front of the series of plates of ground glass upon which are unfolded the scenes of life in the Municipal Schools of Paris.—La Nature.

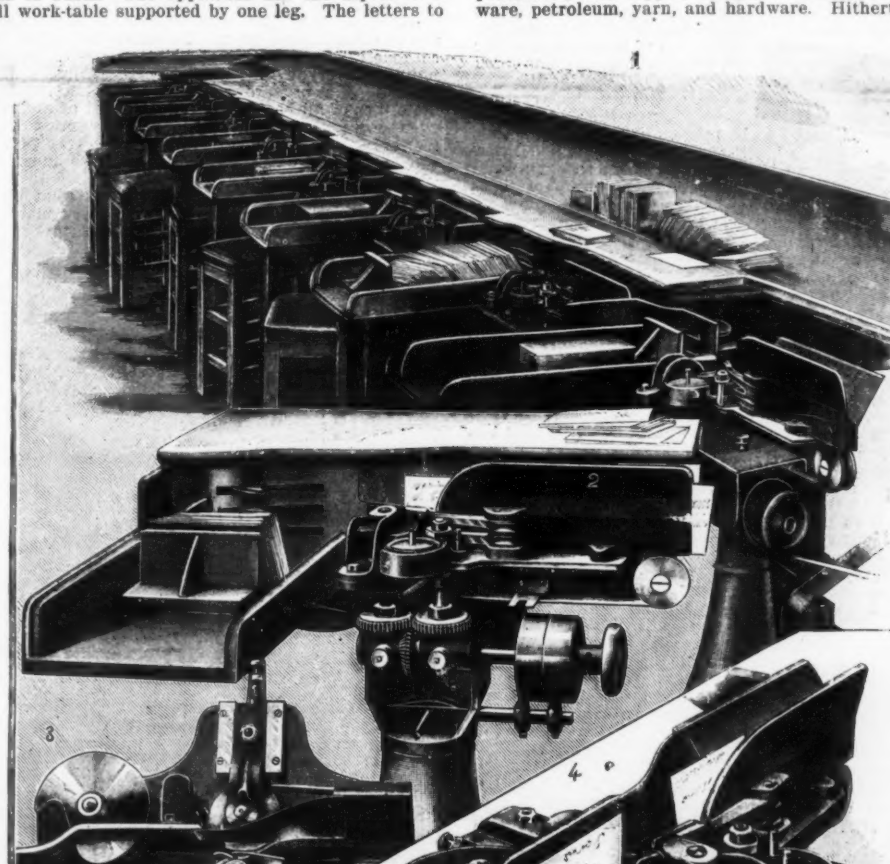
THE PICKERDIKE CANCELING APPARATUS.

THE stamp-canceling apparatus illustrated herewith is of American origin, and after having been used for some time in England and Germany, has at length been adopted by France for use in the large post offices of Paris. The apparatus has the aspect of a small work-table supported by one leg. The letters to be canceled, after having been piled on a table back of the apparatus, are placed one by one in a conduit, whence they are carried along toward an inking roller, and then thrown to the left after cancellation.

An experienced employé can cancel from 180 to 200 letters per minute, that is to say, more than double the number that can be canceled by any other system in the same time. The letters, which are placed vertically, one after another, in the conduit to the right, are carried along by two endless belts, one vertical and the other horizontal, which move at right angles and cause them to pass between two rollers with vertical axes, one of which, with inserted and inked types, leaves its imprint at the moment at which the upper right hand corner of the letter comes into contact with it. The axis of the other roller is movable and is so controlled by a spring as to afford the necessary space for one letter to pass. Upon their escape from the rollers the letters are thrown by a cam upon the plane to the left of the table. The ingenious mechanism regulates the stamping of the letters. All the parts are controlled by a shaft upon which is keyed a pinion that gears with the pieces which distribute motion to the entire mechanism. Upon this shaft is mounted a fast and loose pulley, thus permitting the machine to be quickly stopped and started. The shaft is driven by a small electric motor capable of actuating a series of from 6 to 12 canceling apparatus. For the above particulars and the illustration, we are indebted to La Nature.

THE PRESENT COMMERCIAL CONDITION OF PERSIA.

PERSIA, as it exists to-day, is about three times as large as Germany, but it has only 9,000,000 inhabitants, 2,000,000 of whom are simple nomads, who count but for little as far as foreign trade is concerned. Nearly the whole of the center of the country is a desert of salt and sand, the most fertile regions being the southwest border toward the Persian Gulf and the Tigris district, the Elbrus Mountains and part of the province of Khorassan, in the northeast of the country. But even in these parts the soil produces its fruits only if naturally or artificially watered. While Mesopotamia by a regular management of the water supply may again relatively be brought to a high state of culture, Persia, as far as the largest part of it is concerned, must from the lack of large rivers remain sterile for all time. This is the opinion of a Persian correspondent of the Deutsches Handels Museum, who also states that railroads are still entirely wanting, and the transport by caravans enhances the cost of the traffic considerably. Importation into Persia by the sea route has not progressed during late years; that of arms, cotton goods, loaf sugar, candles, drugs, porcelain goods, matches, etc., decreased last year; while there was an increase in the importation of provisions, tea, copper, indigo, woolen goods, glassware, petroleum, yarn, and hardware. Hitherto, Eng-



THE PICKERDIKE CANCELING APPARATUS.

1. Series of canceling apparatus actuated by the same electric motor. 2. Mechanism of the apparatus. 3. Details of the mechanism for canceling and throwing out a letter. 4. Passage of a letter over the inking roller.

lish influence predominated, especially in Southern Persia. Of the £4,000,000 at which the value of the imports into Persia was estimated, about £1,000,000 came via Bushire, of which £985,000 were contributed by Great Britain. Since fully ten years ago, i. e., since the opening of the Karun River, Russia and England have competed to reach Teheran from the Caspian Sea, and from the Persian Gulf, in which the first-named power through her great energy has made such a start that it will hardly ever be recovered by any other power. If Russia once opens Northern Persia as far as Teheran it will acquire a claim to extend her influence also to Southern Persia.

RECENT SCIENCE.*

I. UNSUSPECTED RADIATIONS.

THE sensation created five years ago by the discovery of the Roentgen rays had hardly begun to subside, and the patient, minute exploration of the newly-opened field was only just beginning, when new and new discoveries of formerly unsuspected radiations came to add to the already great complexity of the phenomena, upsetting the provisional generalizations, raising new problems, and preparing the mind for further discoveries of a still more puzzling character. At the present time the physicist has to account for not only the cathode and the X or Roentgen rays, but also for the "secondary" or "S-rays" of Sagnac, the "Goldstein rays," the "Becquerel rays," and, in fact, for all the radiations belonging to the immense borderland between electricity and light. Nay, most fundamental questions concerning the intimate structure of matter are being raised in connection with these investigations; and the physicist cannot elude them any longer, because one of his most important principles, established by Carnot and generally recognized since, seems also to require revision, or has, at least, to receive a new interpretation.

So many different "rays" are now under consideration that it is necessary to begin by well defining them in a few words, even at the risk of repeating things already said in these pages and generally known. The "vacuum tube" is the starting point for all new radiations, and in its simplest form it is, as is known, a sealed glass tube, out of which the air has been pumped, and which has at each end a piece of platinum wire passed through the glass and entering the tube. When these two wires are connected with the two poles of an induction coil, or the electrodes of an influence electrical machine, or a powerful battery, they become poles themselves. The tube begins to glow with a beautiful light, and a stream of luminous matter flows from its negative pole, the cathode, to the positive pole. These are the cathode rays, the detailed exploration of which was begun years ago by Hittorf, but won a special interest when Crookes took them in hand, and once more when the Hungarian professor, Lenard, began to study them in the years 1893-95. It is evident that the glass tube may be given any shape that is found convenient for some special purpose, and that the degree of exhaustion of air (or of any other gas with which the vessel was filled before exhaustion), the forms and the disposition of the two poles, as also all other details of construction, may be varied at will, according to the experiments which are intended to be made. Now, if such a tube be placed inside a black cardboard muff which intercepts its light, and if it be brought into a dark room near to a screen painted with some phosphorescent substance, this substance begins to glow, although no visible light is falling upon it. If a wire be placed between the tube and the screen, its shadow appears on the screen, and if the hand be placed instead of the wire, dark shadows of the bones, but almost none of the flesh, are projected; a thick book gives, however, no shadow at all: it is transparent for these rays. Some radiations, proceeding along straight lines, must consequently issue from the tube and pass through the cardboard muff. Like light, they make the phosphorescent screen glow, move in straight lines (as they give shadows), and decompose the salts of the photographic film; but they are invisible and pass through such bodies as are opaque for ordinary light. These are the X or Roentgen rays.

Various secondary rays originate from them. If the Roentgen rays meet a metallic mirror, they are not reflected by it, but simply diffused—that is, thrown irregularly in all directions; and, although they do not pass through metals as a rule, they may be made strong and penetrating enough to pass through thin metallic plates. But in both cases they will acquire some new properties which will depend upon the metal which has diffused them or through which they have passed. Some new radiations will be added to them, and these radiations were named secondary rays, or S-rays, by M. Sagnac, who discovered them. On the other hand, if cathode rays have been passed through a perforated metallic plate, they also get altered, and in this case they will sometimes be named Goldstein rays. And, finally, there is a very wide set of extremely interesting (also invisible) radiations emitted by phosphorescent substances. They were discovered by H. Becquerel, and named now Becquerel rays or Uranium rays. More will be said of them presently.

This is, then, the world of radiations the very existence of which was mostly unsuspected five years ago, and which have to be explained—the difficulty being in that they link together the Hertzian waves which are now used for wireless telegraphy, the visible light, the invisible radiations in the ultra-red and the ultra-violet parts of the spectrum, the so-called "actinic" glow of various substances placed in the violet portion of the spectrum, and many other phenomena. Light, electricity, magnetism, and the molecular movements of gases, liquids and solids—all of these formerly separated chapters of physics have thus been brought into a most intimate connection and huddled together by these wonderful radiations.

Thousands of most delicate experiments have been made, and hundreds of papers have been written, during the last five years in order to determine the properties and the constitution of these different sorts of rays. Various hypotheses have been advocated, and yet scientific opinion is still hesitating, the more so as new discoveries are made all the time, and they show that we are not yet the masters of the whole series of phenomena brought under our notice. Upon one point only—and a very important one—a certain consensus of opinion begins to be established; namely, as to the cathode rays. Most explorers, including Lenard[1], begin to be won to the idea that the cathode rays are the paths of very minute particles of matter which are thrown at a very great speed from the surface of the cathode and are loaded with electricity. Even under ordinary conditions, when an electric discharge takes place between one metallic electrode and the other, under the ordinary atmospheric pressure in a room, we see that most minute particles of the metal are torn off the negative electrode (the cathode) and are transported in the electric spark. Molecules of air join in the stream, creating the well-known "electric wind," and the air-path of the electric spark becomes electrified to some extent. The more so when the discharge takes place in the extremely rarefied medium of a vacuum tube.[2] In this case the molecules of the rarefied gas, as also the metallic particles joining the current, are transported at a much greater speed, and we see them as a cone of light.

That cathode rays are real streams of particles of matter seemed very probable as early as 1896, when the subject was discussed in these pages.[3] Recent researches tend to confirm more and more this idea. They act as a real molecular or atomic bombardment, and they heat the objects they fall upon; thus, a thin lamella of glass which is placed in their path will be molten.[4] It is also known from Crookes experiments that when a little mill is placed so as to receive them on its wings, it is set in motion; and a back-current seems to be originated at the same time, as has been demonstrated by Swinton.[5] They are deflected from their straight path by a magnet and are twisted along the lines of force. Besides, a weak electrostatic force has upon them the same effect, showing that they are electrified negatively. Perrin[6] and others who followed him have proved that these rays carry negative electricity with them. If they are taken out of the vacuum tube in which they originated to another tube, and are made there to fall upon an electroscope, they discharge it. Negative electricity cannot be separated from them; it follows with them when they are deflected by a magnet; it is their property—not something added to them.

Moreover, it was already noticed by Crookes, and confirmed since by Prof. Thomson, that most of their properties do not depend upon the nature of the gas—air, oxygen, hydrogen, etc.—with which the tube was filled first, and of which a minute quantity always remains in the tube. They appear as a property of matter altogether rather than a property of this or that gas. And when attempts were lately made to measure the sizes of the particles which are carried in the cathode rays, it was found that they are extremely minute—much smaller than the probable size of atoms—while the charges of electricity which they carry with them are relatively great.[7]

All these facts have brought Prof. J. J. Thomson to the conclusion that the matter which is carried in the cathode rays is not ordinary matter, such as we know it in our everyday chemical experience, but matter in a state of a high dissociation. We know that the molecules of all bodies in nature consist of atoms; but even these atoms, small though they must be, are giants in comparison with the particles transported in the cathode streams. Consequently, we must think that the atoms themselves are dissociated in the intensive electric field. They divide into what we may call the primary atoms of some primary matter out of which the atoms of all chemical elements must be built up, and these primary atoms are carriers of electricity.[8] Of course, not every molecule need be dissociated, and some experiments show that the number of dissociated molecules is really very small in comparison with their total number. If one out of each three milliards of molecules is in a state of dissociation, this will do to account for the facts and the measurements which have been made, although many more molecules may have been dissociated in the cathode stream only to be reconstructed after having exchanged atoms with their neighbors.

It must be said in favor of this hypothesis that dissociation under the action of violent electrical vibrations—i. e., the breaking up of molecules into ions, or elementary atoms carrying electricity with them—is familiar to physicists. Besides, if we cannot yet specify what we mean by our atoms "carrying negative or positive electricity," we may imagine that this means carrying a certain vibratory or, perhaps, spiral movement, or any other sort of motion which we prefer not to specify in order to avoid spreading conceptions which may prove to be erroneous. But we know for certain that gases, which usually are no conductors of electricity, become conductors under the influence of electric discharges, as also of the ultra-violet light, or even after having passed through flames. In such cases they become able to transport electricity—that is, some motion or some state unknown, which we name electricity—from one spot of space to another. A stream of dissociated and electrified particles of matter rushing in the cathode stream is thus a very probable explanation—the more so as similar streams are already admitted in order to explain the electro-chemical decomposition of salts and many properties of solutions.[9] The cathode rays would then be "an electric dance of atoms along the lines of force," as Villari and Righi have expressed it.

One question only must be asked: Is it necessary to suppose that the molecules are so dissociated as to set free the "primary matter" out of which the atoms of all elements are composed? Theoretically, there is no objection to this view. Modern science knows that the atoms—or the "chemical individuals," as Mendeléeff would prefer to name them—are only treated as indivisible in the chemical processes in the same sense as molecules are (or rather were) treated as indivisible in physical processes. The modern physicist does not consider the atoms indivisible in the sense Democritus taught it, but in the sense in which the sun is an individual amid the boundless inter-stellar space. He is even inclined to admit that the atoms have a complicated structure and are vortex rings similar to rings of smoke (Lord Kelvin and Helmholtz), or minute systems similar to planetary systems (Mendeléeff).[10] The "dissociation of atoms" would therefore be admissible; but before admitting the ultimate dissociation advocated by J. J. Thomson, can we not find a simpler explanation? Several explorers are inclined to think so, and Dr. Villard points out one possible issue. The cathode rays are, in his opinion, mere streams of hydrogen atoms or molecules—the presence of this gas in all tubes, even the best exhausted, being explained by the particles of water sticking to the glass, or by the decomposition of the alkalies of the glass. One fact certainly speaks in favor of Villard's view: a small cathode ray parts with its oxygen (is reduced) just as if it had been struck by a jet of hot hydrogen. Besides, the spots where the rays fall upon the glass of the tube are blackened, and these black spots, again, are such as if they had undergone a hydrogen bombardment. Moreover, the spectroscope reveals the hydrogen line in the glowing tubes.[11] But all this, while proving the presence of hydrogen in the vacuum tubes, does not speak against the hypothesis of J. J. Thomson, which still remains up till now the most plausible explanation of the cathode rays.

And yet one feels that the last word, even about these rays, has not yet been said. Dr. Joseph Larmor was quite right when he remarked, in his suggestive address delivered before the British Association at Bradford,[12] that the study of the electrical discharge in rarefied gases has conduced us to enlarged knowledge "of all the fundamental relations in which the individual molecules stand to all electrical phenomena." Up till now we took these phenomena in a block; we studied the sum total of the actions of an infinity of molecules in a certain direction. Now we are bound to question the molecule itself as to its speed, its behavior, and its constitutive parts; and we find that a mobility of its component parts must be taken into account instead of the rigidity with which we formerly endowed it.

The philosophical value of this new move in electrodynamics—the value of the principle of action being introduced into the theories of vibration of the formerly "immaterial" ether—is immense, and it is sure to bear fruit in natural philosophy altogether. Ether itself, after having resisted so long all attempts to seize its true characters, becomes dissociated matter, filling space and upsetting many an old preconceived idea. No wonder, then, if it takes us some time before our views are settled upon these new phenomena, so full of unexpected revelations and philosophical consequences.

If the cathode rays are in all probability streams of dissociated molecules which are thrown off the cathode, what are, then, the Roentgen or X-rays? They certainly originate from the former, either in the spot where they strike the glass or, what appears more correct, within the tube itself, in the cathode stream. But are both of the same nature? Roentgen himself indicates many points of resemblance between the two, and considers them in his third memoir[13] as "phenomena probably of the same nature." Lenard goes even a step further: he represents them both as parts of the same scale or of the same "magnetic spectrum;" the X-rays, which are not deflected by a magnet, being at one end of the scale, while a series of intermediate radiations connect them with the cathode rays occupying the other end of the scale.[14] Both provoke fluorescence, both produce similar photographic and electric effects, and both have different degrees of penetration through opaque bodies, which depend upon the source of electricity and the media through which they have passed. Moreover, the X-rays are certainly not homogeneous, and consist of a variety of radiations.

And yet the many analogies which have been noticed between the Roentgen rays and ordinary light stand in opposition to a full assimilation of the X-rays by the cathode streams; and the opinion that, like light, they are vibrations of the ether takes the upper hand.[15] These may be vibrations of a very short wave-length, perhaps a hundred times shorter than the waves of green light; or they may be "longitudinal vibrations," as Lord Kelvin had suggested at the outset;[16] or, as Prof. J. J. Thomson thinks, they may be a mixture of vibrations of different sorts—"pulsations" of the ether, as he puts it—that is, something similar to what is called "a noise" in the theory of sound.

Already in his second memoir Roentgen had indicated that his rays discharge an electrified body, both directly when they fall upon it, and by their action

* Prince Kropotkin, in The Nineteenth Century. Reprinted by permission of the Leonard Scott Publication Company.

[1] Annalen der Physik, 1898, vol. lxiv., p. 279.

[2] I chiefly follow here Prof. J. J. Thomson, who has explained his views in several articles (Philosophical Magazine, October 1897, vol. xliv., 5th series, p. 293; 1898, vol. xlvi., p. p. 576; summed up in various scientific relvews. 8; 1900, vol. lxii., p. 31); and also Dr. L. Zehnder, the author of a Mechanik des Weltalls (1897), in his address before the Freiburg Natural History Society in 1898.

[3] "Recent Science," in Nineteenth Century, March, 1896.

[4] Goldstein's researches into the compound nature of the cathode rays and their effects deserve a special notice. They are published in several issues of the Annalen der Physik for the last few years.

[5] Swinton, in Philosophical Magazine, 1898, vol. xlvi., p. 387; Broca, Comptes Rendus, 1899, vol. cxxviii., p. 356.

[6] Annalen der Physik, 1898, vol. lxvi., p. 1.

[7] J. J. Thomson, Philosophical Magazine, vol. xlvi., p. 528.

[8] Prof. Thomson names them "corpuscles," but this is hardly an appropriate name for such minute subdivisions of the atoms. To the biologist it conveys an idea of organization; and in physics it was used formerly as a substitute for "molecules."

[9] See "Recent Science," in Nineteenth Century, August, 1892, and January, 1894.

[10] Let me mention in connection with this a brilliant article by Mendeleeff on "Matter," in the new Russian Encyclopædic Dictionary, published by Brockhaus & Efron, vol. vi., p. 151.

[11] Dr. P. Villard, in Revue Generale des Sciences, 1899, vol. x., p. 101.

[12] Nature, October 6, 1900, vol. lxii., p. 449, gives it in full.

[13] Sitzungsberichte of the Berlin Academy of Sciences, 1897, p. 576; summed up in various scientific reviews.

[14] Annalen der Physik, 1897, vol. lxiii., p. 253.

[15] See Geitler's objections against such an assimilation, based upon their different behavior toward electrified bodies (Annalen der Physik, vol. lxvi., p. 65), to which it may be added that the heating effect of the first radiations is very much smaller than the same effect of the latter (E. Dorn); and compare these remarks with the anode current, the existence of which was maintained by Crookes since 1891. Swinton (Phil. Mag., 1898, xlvi., p. 387) confirmed its existence, and Riecke (Annalen der Physik, xlvi., p. 954) has measured its energy.

[16] See Nineteenth Century, March, 1896, where the meaning of this suggestion was explained.

upon the surrounding air, which they render a conductor of electricity. This was an important remark, because the researches of the previous four years had firmly established that the violet rays—i. e., the short waves of light—as well as the invisible ultra-violet radiations, have the very same effect. A link was thus established between the problematic rays and common light, and some of the best physicists (Lord Kelvin, Righi, Perrin, Guggenheimer, Villari, Starke, and many others) engaged in minute experimental work in order to specify these analogies. The result was that the resemblance between the X-rays and the short-waved radiations of light was proved.

A further confirmation of the same analogy was given by the discovery of the "secondary" and "tertiary" rays by the Paris professor, G. Sagnac.[17] He studied what becomes of the Roentgen rays when they strike different metallic surfaces. They are not reflected by them, but only diffused irregularly; however, this diffusion differs from reflection, not only by its irregularity, but still more by the fact that the character of the "secondary" radiations (or "tertiary," if they have been diffused twice) is altered. They become more like ordinary light. Their power of penetration through opaque wood or the human flesh is diminished; and just as a phosphorescing surface which has been struck by ultra-violet radiations begins to glow with a yellow or green light—of a diminished wave-length, as G. G. Stokes had remarked it—so also the diffused secondary radiations behave as if they were of shorter wave-lengths than the rays which originated them. The space between the violet light and the Roentgen radiations is thus bridged over, their analogy with light becomes closer, and the hypothesis according to which they are treated as vibrations of the ether gains further support.

Many other curious properties of the Roentgen rays have been revealed during the last four years. The most interesting is that they are not quite "invisible light." When they are of a great intensity they become visible. However, the portions of our retina which are excited by them are the peripheral parts only, which contain more rods than the central parts lying opposite the iris. The cones, or those constituent parts of the retina which are supposed to convey to our brain the color sensations, are, on the contrary, but very slightly, if at all, irritated by the X-rays.[18] Then the more perfect is the vacuum in a Crookes tube, and consequently the greater is the electrical force required to originate Roentgen rays, the more penetrating they are. In such cases they pass through metals, and Roentgen himself has photographed bullets inside a double barreled Lefaucheux pistol, while other explorers have obtained radiograms with rays which had passed through an aluminium plate 1.4 inch thick, and even a cast iron plate nearly one inch thick.[19] The inside of a watch which had a steel lid, the inner mechanism of a lock, as also both sides of a bronze medal were photographed in the same way; while, on the other hand, Goldstein obtained beautiful radiograms showing the internal structure of a Nymphæa flower, of a hermit crab inside its shell, and so on.[20]

But the chief progress was made with the medical applications of the Roentgen rays. The half-mystical enthusiasm of the first days, when they were supposed to provide a new curative method, rapidly subsided. But their usefulness for ascertaining lesions in the bones, and for the discovery of the actual position of strange bodies—bullets, needles, and so on—in the human tissues, has grown in proportion as surgeons have learned better to handle them.

(To be continued.)

AUSTRALIAN LEATHER.

THE history of the Australian leather manufacturing industry dates from the earliest years of settlement, and at the present time there are, in New South Wales alone, over a hundred tanneries in active operation, employing nearly 1,200 hands, and having a plant valued at £64,500. A large proportion of the leather is consumed in the local production of boots and shoes, of which 3,207,196 pairs were made in New South Wales in 1899, the number of factories being 79, and of the hands employed 3,510. Machinery of the latest and most approved description is used in all the factories. Sydney forms the great center of the New South Wales leather trade, being not only the great shipping port, but also connected by rail or steamer with Bathurst, Orange, Mudgee, Glen Innes, Wagga Wagga, Albury, Penrith, Windsor, Braidwood, Armidale, Tamworth, Parramatta, Grafton, Ulladulla, Bega, and other places in which the leading tanneries, other than those in the metropolitan suburbs, are located. Several of the manufacturers' brands are well known in the London and other markets. In addition to the large quantity of New South Wales material used in the local leather industries, a considerable quantity is exported. In . 99 the value of the New South Wales leather exports was £421,439, of which £374,592 represented the value of the colonial-made leather shipped to Great Britain. The great bulk of the tanning used by New South Wales tanners consists of wattle or mimosa bark, the produce of various specimens of acacia. This bark yields a higher percentage of tannin than any other known vegetable material, with the exception of a bark found only in New Zealand. The bark is usually gathered in the spring, which, in Australia, commences in September, corresponding with March in the Mother Country, although the New South Wales climate at that period of the year more resembles that of an English June. Considerable quantities of wattle bark are exported to the British market, the value of the shipments during 1899 being over £2,000. Formerly the exports were on a larger scale, but the increasing local demand is absorbing the greater portion of the available supply. At one time it was feared that the supply would become exhausted, but immense numbers of the tree, which is a rapid grower and easily cultivated, have been planted by the colonial government and private growers. Many varieties of the wattle are extremely beautiful, with graceful, waving, feathery foliage, and several have highly perfumed white or yellow colored flowers in luxuriant profusion. The quantity of leather imported into New South Wales is limited, and steadily decreasing. In 1899 the value of the imports from the United Kingdom was £15,568; France, £1,527; Germany, £4,512; United States, £43,282. The American sole and upper leather is considered the best imported, and always commands the highest prices.

[17] He gave an account of his researches in Revue Generale des Sciences, April 30, 1898.

[18] Prof. Elihu Thomson's address delivered before the American Association of Science in 1899 (Science, 1899, vol. x., p. 236; translated in Naturwissenschaftliche Rundschau, xiv. p. 585).

[19] Radiguet, Sagnac, Hall Edwards.

[20] Max Levy, "Fortschritte der Roetgentechnik," reproduced in various periodicals.

[Continued from SUPPLEMENT, No. 1306, page 20930.]

THE STEAM TURBINE: THE STEAM ENGINE OF MAXIMUM SIMPLICITY AND OF HIGHEST THERMAL EFFICIENCY.*

By ROBERT H. THURSTON.

A SUCCESSFUL steam turbine involves the determination of the precise forms and proportions of the jets supplying steam to the machine; their proper length and sweep; the similar problem of the vanes and channels in the wheel; the best speed of rotation and size of disk for the stated conditions; the safe construction of the revolving disks; the choice of a metal for these disks capable of safely sustaining the enormous stresses of centrifugal forces, and of carrying with safety, and without distortion, the buckets set on its periphery where not solid with the wheel; the provision of perfect static and running balance and equilibrium; the reduction of friction of disks spinning 25,000 revolutions a minute, in some cases even more, in contact with high pressure steam on the one hand and the vapor of the condenser or the air on the other, and the free and certain and economical lubrication of rubbing surfaces of metal in journals and bearings.

The principles involved in these several problems of detail are usually very simple, and are well understood by every well-informed engineer. The steam pressure must be as high as practicable; the fluid must develop fully its energy of flow from the latent energies of the steam stored at the boiler; these energies must be as gradually and steadily developed in useful form as possible, in guide channels formed so as to produce maximum velocity of delivery without loss by eddies or friction or leak. The steam should be delivered upon the wheel and entered into its channels without shock or leak or irregularity of flow, and must leave them with minimum mechanical energy, just flowing out of the way of the succeeding particles. Speeds of rotation must be precisely those exacted by the pressures adopted; proportions of receiving and delivering sides must be similarly adapted to the work; materials must be not only strong but tough; fits must be accurate, without permitting contact of parts having rapid relative movement; lubrication should be effected with a suitable unguent flooding the parts; steam should be superheated, and the vacuum as perfect as possible.

In all forms the obstacles to be overcome by the engineer are the same, and, as a rule, similar expedients are adopted by all for the purpose. In all, the speed of linear travel of the turbine vane must be enormously great, too great, by far, for satisfactory attainment, or for convenient utilization in connection with other mechanisms, and in all the ultimate velocity of exit from under pressure cannot be made, after a moderate pressure is attained, to increase with rising boiler pressures, if issuing from plain orifice; and in all it is a problem of importance to secure the issue of the steam in a compact and well-defined jet, capable of being directed with precision into the receiving buckets of the wheel. To secure this compact jet and to turn it, at its enormous velocity of issue, into buckets flying at not less than one-half this velocity, and in them to so manipulate the kinetic energy of the fluid as to absorb without waste any large proportion of its total, constitutes the problem for all—a very simple but a somewhat difficult one, and one which does not permit departure from very simple and inflexible principles and processes.

The principles are precisely those of hydraulic-turbine construction and operation:

1. The full energy of the available head should be developed.

This may, as in the water-wheel, be either developed by immediate and complete conversion into the kinetic energy of a freely-moving jet before any portion is transformed into useful work, or it may be partly developed as purely kinetic energy and partly as the energy of pressure overcoming the resistance of the load directly, as illustrated in the case of the hydraulic motor, by the impact and the pressure turbines. Ordinarily, however, the steam turbine, even more than the water-wheel, is best operated on the first system, as it is less liable to leakage or waste.

2. All sources of waste, during the process of production of utilizable kinetic energy, as through friction, leakage or irregularity of flow, or in the form of a jet, should be anticipated and provided against effectively, in such manner that the full amount of available primary energy may be developed.

3. The transfer of the energy of the jet to the turbine should be completely effected. The jet should be directed, precisely, into the buckets; it should be taken into the passages of the wheel without disturbance of its flow; should be guided steadily and smoothly into a reversed path; should be brought to a relative velocity on the vane nearly equal to the velocity of the latter with respect to the earth, and should be then allowed to issue with minimum final velocity and store of kinetic energy, and with expansion as complete as practicable, into the atmosphere or the condenser. Meantime, the passages should be smoothly graded in cross-section from the point of reception of the jet to the point of discharge, in such manner that the law of flow just enunciated should be maintained and the proper relation of increasing volumes and decreasing pressures preserved, without sudden variations of rate of flow.

These principles being observed, the form of the apparatus or the type of the machine will have no influence upon the efficiency attainable; but the compliance with these conditions of maximum effect, while seeking low speed of rotation and the satisfaction of the demands of practical construction and application to specified purposes, may involve, as elsewhere seen, the exercise of much ingenuity and great constructive skill, and may give rise to a variety of forms of detail. The essential requirement at the point of delivery of the current upon the turbine is attained by careful shaping and proportioning of the nozzle with a view to insuring steady volumetric change and steady flow, from the interior of the boiler to the orifice, from which a compact and straight-lined jet is to issue. The essential requirements in receiving the jet upon the wheel and in converting its kinetic energy into useful work, are the smooth and gradual change of section of the wheel passages from point of reception to point of final delivery of the fluid from the turbine, while providing for equally smooth and steady change of direction of flow, relatively to the wheel and to the earth, in such manner that the flow will be ultimately completely reversed on the wheel and reduced to as nearly zero as may be found practicable with respect to the earth; and while securing freedom from wastes by leakage, by friction or by non-adaptation of the speed of rotation of the wheel to both the speed of the jet and the velocity of rotation of the driven mechanism. Meantime, the reduction of fuel and steam consumption to a minimum thus assured, should be accompanied by a reduction to a safe limit, of the weight, volume and rotative velocity of the turbine. The delivery velocity of the jet is usually, in the Laval practice, at least, about 3,000 feet per second; that of the receiving edge of the wheel should be about one-half this speed, or respectively 35 and 17½ miles per minute (2,100 and 1,050 miles per hour). The velocities are actually usually about 1,200 feet per second, nearly 15 miles per minute and 840 per hour, figures which obviously involve enormous centrifugal forces and as extraordinary strength in the materials of which the turbine disk must be composed.

The stored energy of the jet, per unit of weight, is

$$E = Wv^2/2g;$$

which, for the above velocities per second of the effluent steam, becomes

$$E = 3{,}000^2/64.4 = 140{,}000 \text{ feet-pounds nearly,}$$

for each pound weight of steam supplied. This energy is so great and the inertia of the mass so effective, that it is found by direct experiment that there is very little tendency for the jet to expand laterally, where permitted opportunity to move forward, as when entered into the wheel-passages immediately on issuing from the jet-nozzle. It is also evident that the design of the turbine is, apart from properly proportioning the passages, mainly a problem in meeting the inertia or centrifugal stresses, and that the steam pressures dealt with are comparatively unimportant. It is for this reason that, in small turbines, the passages are milled out of solid steel disks and that, in all cases, metals of high tenacity are selected for their construction.

Where the compound-turbine is adopted, and the velocity of rotation is reduced to a fraction of that exacted in the simple turbine of high efficiency, strength of material is less a problem; but, even with the lowest speeds as yet secured, these forces are not to be ignored. With the compound-turbine, the same proportions of successive sections of wheel and guide passages are to be provided; but they are distributed over a path which wanders from jet to wheel, to guide, to wheel again—from the one to the other alternately—sometimes, as in some of the Parsons turbines, through the passages of 30 or even 40 disks and their accessory guides. The proportions are easily determined by laying down the adiabatic curve for the case assumed and making the passages follow in their relative sections the order, relatively to pressures, thus found. For velocities, the formula of Zeuner may probably be accepted as substantially correct. This gives, for expansion from 6 atmospheres to 1, a velocity of outflow of jet of 2,600 feet per second and the velocity into a vacuum, giving 0.1 atmosphere back-pressure, from the same initial pressure, 4,600 feet.

The discharge may be computed by Napier's formula,

$$W = pa/70;$$

where W is the weight discharged per second; p is the absolute steam-pressure in pounds per square inch; a is the area of the orifice in square inches; and 70 is the constant determined by Napier's original experiments. This formula was checked by a series of experiments in the Sibley College laboratories, in 1897-8, using a nozzle of the type employed in the steam turbine, but only ⅜ inch in length and with carefully rounded entrance, and while shapes and proportions of nozzles and method of dealing with the exeunt steam in measuring it were found to affect the results, it was concluded that the formula was substantially correct for the case in hand.

The wastes of energy in the steam turbine differ, in some respects, as to character from those of the common type of engine, and consist of losses by conduction and radiation, in small proportion from the exterior of the system, as in the ordinary machine, of friction wastes of small amount in the turbine, so far as produced by rubbing of parts in contact, as contrasted with comparatively large amounts in the reciprocating engine, and of often large amounts of fluid friction in the turbine within the working apparatus as compared with very small quantities within the steam cylinder of the piston machine; while the latter is subject to large losses through "cylinder condensation" for which no equivalent appears in the turbine. Leakage probably is the cause of much larger wastes in the turbine, proportionally, than in the standard engine. Vibration and jar occur in serious degree, at times, with the reciprocating engine and are absent from the properly built turbine.

Of these losses, the external wastes by radiation and conduction can be, in either engine, made unimportant by careful protection by non-conducting coverings; leakage requires more perfect construction in the turbine for its extinction, than in the ordinary motor; friction in the former is so largely internal, and especially is in such proportion fluid friction, that it is in less degree subject to absolute waste as energy; since it is productive of heat in full proportion and this heat assists in maintaining the steam dry during

*Paper read at the New York meeting (December, 1900) of the American Society of Mechanical Engineers.

the period of expansion and promotes adiabatic expansion by compensating the losses of heat externally. By extending the period of expansion also, until an equivalent amount of energy is developed, before rejection from the turbine disk, this equivalent heat and work can be regained in cases in which the expansion is not originally complete, always provided, of course, that the added work of expansion does not exceed, in total cost, the value of the recovered energy. The comparatively large internal friction thus affords opportunity for recovery in the turbine in larger proportion than in the ordinary machine.

We have found reason to believe that the friction of fluids in contact with the spinning disk of the turbine or in the eddying stream of fluid may have an important influence upon the efficiency of the turbine at such enormous speeds of relative motion as we find in this apparatus. The total friction of the 10 horse power Laval turbine of Sibley College is 2.4 horse power, nearly ¼ its ratio delivery, and practically constant, of course, at all loads. The rate of absorption of energy of a turbine disk spinning, initially, 15,000 revolutions per minute, in steam at atmospheric pressure, was found by Wissler, at Sautter-Harle, to be, as a mean, 3,000 revolutions per minute, and the whole energy of the disk considered as flywheel was lost in 5 minutes, converted into the work of friction of disk and bearings, apparently in nearly equal parts, and reconverted into wasted heat.

A weight of 10 pounds, spinning with a mean velocity of only 100 feet per second, would store energy amounting to

$$10 \times 10{,}000/64.4 = 1{,}553 \text{ feet-pounds.}$$

At the more common mean velocity of high-speed turbines, it would store

$$10 \times 90{,}000/64.4 = 13{,}977 \text{ feet-pounds.}$$

If this were lost in five minutes, the deduction follows that about 2,800 feet-pounds may thus be transformed into friction per minute and within an atmosphere of dry steam issuing from a non-condensing turbine, or if the turbine be rated at 10 horse power, a mean of about 1 per cent of its nominal power, a loss increasing with the proportion of moisture present; while at the maximum the loss would, at uniform full speed, be several times that figure.

Leakage is obviously a serious matter with these motors, and the closest of fits and finest of workmanship is needed to insure against a large loss of efficiency through this action. When it is realized that a nozzle of a square-inch section may supply steam for 3 to 500 horse power in steam motors, and that a clearance of but one one-hundredth of an inch around the circumference of the turbine disk will permit some such waste, it is easily seen that here may often be a reason for the falling off of the output and the economy of the machine 50 per cent or more. The desideratum at this point is absolute tightness of fit with liability to rubbing friction and variation of fit with pressure or temperature. It should be possible to secure an efficiency with the steam turbine, practically equal to that of the best hydraulic turbine, approximating 80 per cent, but not until fluid friction and leakage can be substantially suppressed.

The Rankine cycle being taken as representative of the ideal case of the turbine as now constructed, we find that the measure of the utmost effective work of the machine operating between p_1 and p_2, T_1 and T_2, as deduced by both Rankine and Clausius, is

$$U = J\left(\int_{T_2}^{T_1} C\frac{T_1 - T_2}{T_1} \cdot dT + \frac{T - T}{T_1} \cdot r\right);$$

where measured in dynamic units and when U is in feet-pounds J is 778; C is the specific heat of the liquid at absolute temprature, T_1; and r is the latent heat of vaporization at the same temperature in thermal units. All the constants are well known and very accurately determined by Regnault and his successors. The quotient of this quantity, in any given case, by the mechanical equivalent of the heat supplied in production of the steam yielding this work, measures the efficiency of the operation; which rarely equals one-fourth in the very best of existing actual heat motors and which is now usually about 20 per cent in the best classes of steam engines operating with dry steam of high tension and with large expansion.

Approximate expressions of convenient form and sufficiently accurate for general use by engineers have been proposed by various authorities, among whom Rankine was one of the most successful; as, for example, where he finds, for the case of the non-conducting cylinder, the equivalent of the case in hand:

Energy per cubic foot of steam admitted,

$$E_v = r\,p_e = r\,(p_m - p_3) = p_1\,(10 - 9r - \tfrac{1}{9}) - rp_3;$$

where r is the true ratio of expansion; p is the mean effective pressure; p_m is the mean total pressure; $p6$ is the back pressure; all in British units, pounds, feet and foot-pounds.

The heat expended is similarly found to be, approximately, in foot-pounds per cubic foot:

$$HD/r + (13\tfrac{1}{3}{}^{\circ}{}_1 \times 4{,}000] - r;$$

where H is the heat per pound and D the weight per cubic foot of the fluid; p_1 is the pressure per square foot, as above, at the boiler.

The Ideal Rankine Non-conducting Engine, with 2 pounds back pressure, and a terminal pressure on the expansion line of 7 pounds per square inch, should have an efficiency measured by a consumption of heat in British thermal units per horse power per hour of about

$$H = 20{,}000/\log.\ p_1 \text{ (ideal).*}$$

A criterion by which such an engine may perhaps be best judged and compared with other steam engines of varying conditions, especially steam pressure, is the magnitude of the value of the constant a in the expression for quantity of heat consumed, per horse power per minute or per hour, already given,

$$H = \frac{a}{\log\ p_1}.\dagger$$

The values of the constant, a, have been found to be, for the ideal case of Carnot, about 18,000 British thermal units per hour, and to range upward to 36,000 for the best classes of simple engines; while the best examples of triple and quadruple-expansion machines give, respectively, about 27,000 and 26,000 where p_1 is the steam pressure in pounds on the square inch.

The best records for the simple engine with dry and saturated steam, to date, appear to approximate

$$H = 36{,}000/\log.\ p_1 \text{ (simple)};$$

those for the best compound engines similarly approach

$$H = 32{,}000/\log.\ p \text{ (compound)};$$

those for the best class of triple expansion engines give

$$H = 27{,}000/\log.\ p_1 \text{ (triple)},$$

and those for the best class of quadruple expansion engines attain approximately

$$H = 26{,}000/\log.\ p_1.$$

For dry, saturated steam, such as is probably fairly to be assumed to be secured with moderate superheating in the steam-turbine and where only adiabatic condensation takes place, Rankine obtains approximations, thus:

Energy exerted on the engine by one pound of steam—

$$U = v_2\left\{p_1\,(17r^{-1} - 16r^{-\frac{17}{16}}) - p_3\right\};$$

where v is the volume at the end of expansion; p_1 and p_3 are the initial and back pressures; r the total ratio of expansion as before.

Heat expanded per pound of steam:

$$H = 15\tfrac{1}{2}\ p_1 v_1 = 15\tfrac{1}{2}\ p_1 v_2/r^*.$$

MM. Rateau and Rey have found approximate expressions for metric measures of the consumption of steam for the ideal case, the quantity of work per unit weight being the maximum, as above, and give

$$K = 0.85 + (6.95 - 0.92 \log.\ p_1)/(\log.\ p_1 - \log.\ p_2);$$

where p_1 and p_2 are the initial and final pressures.†

Pressures are in kilograms per square centimeter; K in kilograms per metric horse power hour. The formula is stated to be correct to within 0.002, for values less than 15 kilograms per horse power hour. M. Rateau calls attention to the fact that the formula exhibits clearly the advisability of insuring a low back-pressure and, with condensation, a very perfect vacuum.‡

Prof. Mollier, in 1898, proposed the following:

$$K = 0.85 + (6.95 - 0.92 \log.\ p_1)/(\log.\ p_1 - \log.\ p_2);$$

which is a trifle less accurate, but simpler.§

The proportion of steam condensed in adiabatic expansion is known to be accurately:

$$m_e = 1 - T_2/H_2 \,.\, \left(J \log_e \frac{T_1}{T_2} + \frac{H_1}{T_1}\right);$$

where T_1 and T_2 are absolute temperatures, initial and final, and H_1 and H_2 are corresponding latent heats of vaporization. The values of m_e range, from insignificant amounts, in the older forms and proportions of engines employing low steam pressures, to about 1½ per cent per unit ratio of expansion, as operating in modern engines at high pressures and as observable in the steam turbine.|| For example: It amounts to 15 per cent in expanding, as in the triple-expansion engine, from 140 pounds to 7 and to 10 per cent between 140 and 20 pounds, absolute, and is nearly in proportion to the reciprocal of the ratio of expansion at low initial pressures and moderate cut-offs.

The Discharge from Steam Nozzle, and orifices in thin plates as well, differs very greatly from the discharges from similar conductors of liquids, since the elasticity of the fluid comes into play and the ratio of pressures, initial and final, in practice is very great in the steam motors. The weight flowing from the nozzle, per unit of time, is measured by

$$W = VDS;$$

where V is the velocity, D the density of the fluid at the point taken for measurement, and S is the section of the current at the same point. With the liquids, where density is constant, the section is thus proportional to the weight discharged; but the vapors and gases have a varying density during flow and, as the pressure falls and specific volume increases, the weight discharged, increasing at first, soon becomes a maximum and thenceforth decreases with falling tension. This point of maximum discharge is found at about $p_2/p_1 = \frac{1}{2}$ for the gases and about $p_2/p_1 = 0.6$ with vapors, at all initial pressures. For steam, the ratio is usually given as about 0.58. This action was detected by Napier in experimental work and explained by Rankine, then engaged in the study of the thermodynamics of the case.*

It follows from this that, to secure full delivery and continued acceleration of the jet, the nozzle should converge from the point of maximum pressure within to a minimum section where discharging the total flow at 0.6 initial pressure and should thence diverge as pressures continue to fall, and in proportion to such drop. The exit orifice should thus be given, finally, a section proportioned to that of minimum section, for $p_2 = 0.60\ p_1$, as the latter pressure is to p_3 at final discharge from the system.†

If the jet is not thus let down to the pressure of the atmosphere, the condenser or other receiving medium, it expands to that minimum immediately at exit and enlarges its section in similar proportion and is then ready to surrender its energy. The nozzle thus is to be given a converging or a diverging form, accordingly as the pressure at its exit is greater or less than the critical tension just indicated, and as illustrated by the long-current practice of the makers of Giffard's "injector" and perhaps of still earlier makers of apparatus in which such a jet is sought. The earliest turbines of Laval, and his predecessors even, illustrate the fact enunciated by the inventor, that diverging nozzles must be employed, if seeking to obtain the full advantage of the fall of pressure, from initial to terminal, outside the turbine wheel. The discharge of steam from the nozzle is thus independent of the final pressure when the latter is less than 0.6 the initial pressure, although a function of that tension at higher proportional tensions.

The computation of the velocity, V, of flow of jet is effected by expressions like, or equivalent to, that of Wantzel and Saint-Venant as early as 1839, in a discussion of experiments on the flow of air.

This equation has the general form

$$V_2 = \int_{p_2}^{p_1} v\,dp;$$

which can be integrated when the relation of v to p can be established for the assumed conditions as for isothermal or for adiabatic expansion, and when the values of constants in the familiar expression, pv^γ = constant, can thus be determined. In the present

STEAM-TURBINE CYCLES.

Rankine-Clausius Cycle: No Compression.

Ideal case; $p_3 = p_2 = 2$; condensing; $T_2 = 587°$.

p_1	150	200	250	300	350	400	450	500
T_1	819.22	842.63	861.88	878.369	892.96	905.9	917 62	927.2
r	14.87	19.34	25.	27.4	31.4	35.4	39.17	43.02
V_2	44.04	43.25	42.6	42.06	41.55	41.25	40.82	40.5
H_1	858,289	863,813	868,411	872,323	875,827	878,890	881,707	885,000
U	197,624	212,305	223,805	233,120	232,231	242,042	256,526	262,050
E	23.	24.5	25.87	26.7	26.5	27.5	29.09	29.6
M.E.P.′ ...	4,521	4,908	5,188.7	5,260	5,583	5 875	6,170	6,375
M.E.P.″ ...	31.16	34.2	35.5	36.6	38.77	40.75	42.64	45.5
A	11,065	10,386	9,910	9,875	9,603	9,254	8,748	8,600
B	2.3	2.29	2.28	2.27	2 26	2.25	2.25	2.24
C	10.	9.35	8.88	8.52	8.54	8.36	7.7	7.57
W	11.4	10.7	10.3	10.2	9.9	9.2	9.0	8.9
F	1.107	1.03	.991	.987	.96	.925	.875	.843
D	440.4	397.	387.1	376.2	355.	328.	316.	306.3
D'	7.3	6.7	6.4	6.2	5.9	5.6	5.3	5.1

Carnot Cycle: Full Compression.

Ideal case; $p_2 = p_3 = 2$; corresponding to $T_2 = 587°$.

p_1	150	200	250	300	350	400	450	500
T_1	819.2	841.6	861.9	878.36	892.9	905.92	917.6	928.4
r	44.8	57.8	70.4	82.63	94.6	106.5	118	129.6
V_2	133	130.4	128.4	126.83	125.4	124.2	123.3	122
H_1	671,000	656,000	646,097	636,604	628,219	620,797	613,000	607,618
U	190,000	198,500	205,000	210,079	218,900	218,500	221,000	222,000
E	28.3	30.3	31.9	33.1	34.2	35.1	36.	36.7
M.E.P.′	1,427	1,522	1,604.9	1,695	1,712.1	1,758.2	1,800	1,820
M.E.P.″	10.01	10.56	11.13	11.55	11.85	12.2	12.5	12.7
A	9,000	8,430	7,986	7,730	7,450	7,236	7,050	6,934
B	2.95	3.02	3.08	3.11	3.15	3.19	3.23	3.26
C	10.45	9.98	9.69	9.4	9.2	9.0	8.94	8.89
W	9.32	8.73	8.27	7.93	7.73	7.49	7.32	7.19
F	.90	.832	.799	.773	.745	.724	.705	.698
D	1,390	1,300	1,236	1,190	1,157	1,115	1,100	1,090
D'	22.8	21.7	20.6	19.9	19.28	18 58	18.3	18.1

* "Standard of Efficiency for Heat Engines," Journal Franklin Institute, December, 1896, January, 1897. R. H. Thurston; also "Manual of the Steam Engine," fourth edition, p. 1002. Trans. A. S. M. E., 1891.

† "See "Manual Steam Engine," vol. i., chap. viii.; Trans. A. S. M. E., 1889.

* Rankine's "Prime Movers," part iii., chap. iii., sec. v., p. 375. Thurston's "Manual of the Steam Engine," vol. i., chap. v., p. 421.

† "Annales des Mines," Fevrier, 1897.

‡ "Rapport sur les Turbines à Vapeur," Congres International de Mécanique, Paris, 1900.

§ Zeitschrift des Vereines deutscher Ingenieure, June, 1898.

|| "Manual of the Steam Engine," vol. i., pp. 439-440.

* Rankine's "Prime Movers," p. 298, London Engineer, September, October, November, December, 1869. See also Rateau, "Rapport sur les Turbines," 1900.

† It has been found that the maximum velocity at the point of greatest contraction is very nearly if not quite that of sound in the fluid, at that point and in that state as to pressure and volume.

‡ Journal de l'Ecole Polytechnique, vol. xxvii.

case, the expansion is, in steady working, adiabatic actually as well as ideally; $y = 1.135$, and we have

$$V_2^2/2g = p_0^{\frac{1}{\gamma}} v_0 \frac{\gamma - 1}{\gamma} \left(p_1^{\frac{\gamma-1}{\gamma}} - p_2^{\frac{\gamma-1}{\gamma}}\right);$$

in which values may be inserted to correspond with the conditions assumed. Grashof has proposed the approximate and simple formula for the case in which the final pressure falls below the critical,

$$W = 15.26\, p_1^{0.97},$$

and Rateau offers

$$W = 15.42\, p_1^{0.977};$$

where W is in grams per second and per square centimeter of orifice, and p_1 is in atmospheres.

Otherwise deduced, we may assume that the energy of the jet is that of the graphic representation of the cycle, either entropic or pressure volume. Hence, if we divide the measure of the horse power, 5,502 or 33,000, or 1,980/000, for the selected unit of time, by the work, U, of the ideal diagram, the quotient is the measure of the number of units of weight of fluid required per horse power, $W_s = 33{,}000/U$. Thus we have, also, the expression, on the assumption just made, for energy produced in kinetic form,

$$V_2^2/2g = 550\ /\ W_s = U;\quad V_2 = \sqrt{550 \times 2g\ /\ W_s}.$$

In metric measures,

$$V = 100\sqrt{530\ /\ K};$$

where V is in meters per second and K is the steam consumption per horse power in kilograms. Rateau gives also the approximate formula for V:

$$V_2 = 418\ m\ (1 + 0.065\ log.\ p_1),$$

where m represents the meter, p_1 the initial pressure, the terminal being 0.6 p_1.

The Graphics of this Case may be illustrated either by tracing the "*pv* history" of the unit-weight of steam throughout its cycle or by studying the "theta-phi-diagram," the dynamic and the thermal graphical representations of the complete cycle of changes of pressure and volume, and of temperature and entropy which are synchronous with the kinematic cycle of the apparatus; passing through which cycle, each mass of fluid, and each unit of heat finds itself related precisely as at a point in time marking the similar point in the preceding engine cycle. This cycle is easily followed in the case of the piston engine; as it corresponds precisely and necessarily with one revolution, or kinematic cycle, of the engine crank; but it is less readily defined in the case of the steam turbine.

What actually happens is either the following or an equivalent series of operations: Taking unit-weight of fluid employed as the working substance, we find in this case a pound of water, as will be assumed, entering the boiler is presently, under boiler-pressure, raised to the temperature of the steam, with slight increase of volume, then, with no further change of temperature, but with large accession of heat, it is expanded from the specific volume of water to that of the steam; meantime the fluid accepting heat of two nominal sorts: one quantity measured by the product of the range of temperature into the mean specific heat of the fluid, the other the "latent heat," which is transformed automatically into work and employed in overcoming molecular resistance to expansion and vaporization, and in the external work of overcoming the resistance due the pressure of the atmosphere of vapor into which the steam is forced. The first, the actual energy, is stored as heat; the latter, the potential energy of the molecular system of the vaporized fluid, can only reappear on the condensation of the vapor into the liquid again. The changes of pressure and volume of the fluid, in these as in all physical changes, are mutually related, and the laws and the magnitudes for the case are well known. The next movement in the cycle is the transfer of the mass of steam to a point of exit where the fluid expands, adiabatically, through an ajutage, a nozzle, in which all the available thermal energy is, by thermodynamic transformation, converted into the kinetic energy of a jet of steam, issuing with a velocity determined by the magnitude of the store of energy thus utilized. In this process of transformation of stored and potential energy into *vis viva*, the inertia of the freely-moving particles automatically supplies the resistance exactly balancing the expansive effort, at each instant of the expanding vapor, and the relation of pressures and volumes is precisely that observed where, as in the reciprocating engine, the steam expands behind a piston and the same quantity of heat is converted into work by the same series of variations of pressure and volume; the "*pv* history," or the "theta-phi history," of the fluid, during the turbine cycle, and at every step in this progress, is precisely the same as with the corresponding engine cycle so familiar to the engineer as his "ideal" indicator diagram.

The Ideal Cycle for the steam turbine corresponds more closely with that of the real engine than does the ideal of any other form of motor in accord with its real and practical representative. Among the principal representative thermodynamic cycles of both the gas and vapor engines will be found the ideal cycle for all familiar forms of heat engine. It is No. XVIII., but properly including the triangular terminal area, *if* $v^1/_2$, of the vapor-cycle diagram, which marks the difference between the ordinary Clausius and the common Rankine ideal cycles; either of which, however, it may simulate. So far as the process of heat-conversion is concerned, that in which the stored heat-energy of the working fluid is transformed into work by expansion, the turbine cycle is ideally perfect; this expansion line being combined with complete adiabatic compression to produce a Carnot cycle and the perfect heat-engine diagram.

This cycle is also capable of modification, as with the common engine cycle, restricting the volume of the fluid at the termination of the period of expansion within the machine, as is customary in the reciprocating engine, in compliance with the demands of financial and commercial economics. In fact, the steam turbine can be made to closely, if not accurately, reproduce the Rankine cycles, either with or without adiabatic compression, and, in actual operation, to approximate the ideal more closely than other engines, both in form of cycle on the pressure-volume chart and in actual utilization by thermodynamic conversion of the heat-energy supplied it.

Studying the cycle in detail and as modified from that of the "perfect engine" by the omission of the compression line and by incompleteness of expansion, we may compare the two diagrams in which the coordinates are, in the one case, pressure and volume; in the other case, temperature and its complementary factor "entropy;" both diagrams representing the same quantity of energy—that which is derived, in such a cycle as is taken in illustration, by the employment of unit-weight of the fluid.

In the diagrams, Fig. 9 and 10, the perfect engine cycle is represented by *abcda*, the cycle of Rankine or of Clausius, with its complete expansion and without compression, by *abcdea*. In the former, both expansion and compression, *bc* and *da*, are complete and adiabatic and the efficiency of the cycle is necessarily, for the ideal case, for the turbine, as for the common form of engine, the maximum, Carnot, efficiency:

$$E = (T_1 - T_2)/T_1.$$

In the second form, in which there is no complete compression or other, but in which the restoration of the fluid from maximum to minimum temperature and pressure, and from minimum to maximum volume, is effected by expenditure of heat otherwise capable of thermodynamic utilization, the cycle is modified and the diagram becomes thus altered, at the left, by the transfer of its boundary from *da* to *ea* with a loss of efficiency measured by the defect shown by the loss of area exhibited by the conversion of the rectangular area into the triangular, as at *ead*, on the temperature-entropy diagram in Fig. 9, a modification of efficiency which does not appear so satisfactorily on the pressure-volume diagram. The magnitude of the utilized energy is easily shown to be in the second case:

$$U = J\left[T_1 - T_2(1 + log_e\ T_1\ /\ T_2) + \frac{T_1 - T_2}{T_1}\ .\ H_1\right] + P_2 - p_3)v_2;$$

where T_1 and T_2 are the temperatures and p_1 and p_2 are the pressures at the beginning and at the end of expansion and p_3 the back pressure, v_2 the final volume for the case of incomplete expansion.

The increased expenditure of heat, in the second case, that of the Rankine ideal cycle, is shown on the theta-phi diagram as *ead* and the work gained is seen to be, on the *pv* diagram, *ead*; their ratio is obviously less than one-half that of the work *abcd* to the heat expended in the Carnot cycle.* The net result is thus a decided loss and its magnitude in any example may be computed by comparing heat supply and work performed in the two cases.†

It will be noted that, in the preceding algebraic expression for work performed, the last term within the brackets measures the work done and the efficiency of the Carnot cycle; the balance of the bracketed quantity must evidently measure the difference of work for the two cycles for equal differences of temperature and ratios of expansion, but the fact that the gain of work in the Rankine, or the common Corliss engine cycle over that of Carnot involves a net loss of heat and efficiency, a loss of heat more than the equivalent of the gain in work, is not shown by the diagram and must be found by computation or by comparing the two diagrams drawn to a common scale of energy.

Fig. 11 shows the simplest case of development of energy in the jet, and its storage by conversion from heat energy, in a diagrammatic manner. From *a* to *b*, the work of expansion occurs adiabatically; the work of vaporizing taking effect within the vessel, *A*, in which steam is made and producing that acceleration and kinetic energy which is observable at *c* and up to the point at the nozzle at which the adiabatic expansion commences. The work in *A* is shown on the pressure-volume diagram as *abhe*; that of adiabatic expansion is *bchb*. Passing out, along the path, *B*, the fluid stores all the energy measured by the diagram, in the form of *vis viva*, which is to be presently absorbed by the impact turbine. As the store of steam and of energy in *A* is necessarily constant in steady working, it is obvious that all the energy of the vaporization period must enter the jet.

Formal Engine Trials to determine the efficiency in practical operation of the steam turbine are now available in considerable number and among them and in addition to the special investigations made in Sibley College, there are some which throw light upon the question of the extent and manner of gain in efficiency obtainable by the use of superheated steam. Among the earliest of these were those of Prof. Ewing, in August, 1892, in which the Parsons compound turbine was tested. The report upon his investigations includes the following as the main features in data and results of test:

The general behavior of the machine was similar, in respect to efficiency and its variations to that of the ordinary piston engine. The so-called "law" of Willans was illustrated and the performance of the turbine was practically equivalent to that of a good compound engine of the ordinary type and under similar

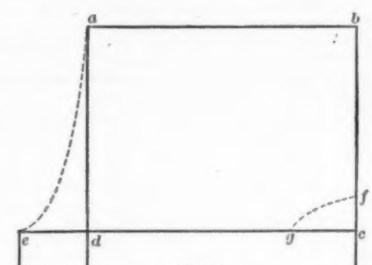


FIG. 9.
TEMPERATURE.-ENTROPY DIAGRAM.

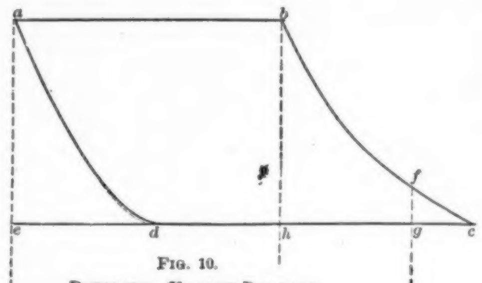


FIG. 10.
PRESSURE. VOLUME DIAGRAM.

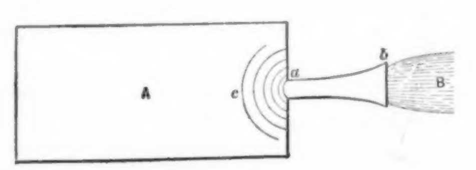


FIG. 11.
THE STEAM JET.

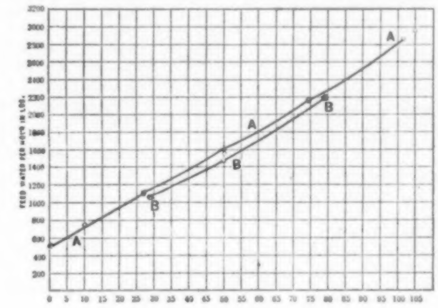


Fig. 12.—Parsons' Turbine.
AA—Steam superheated to about 400° F.
BB—Steam superheated to 465° F.

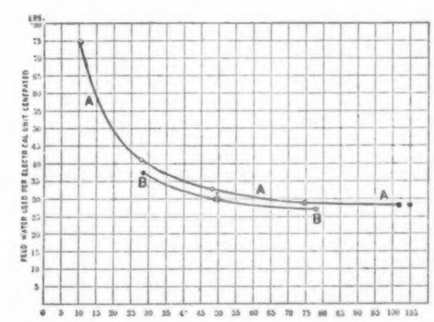


Fig. 13.—Variation of Economy with Change of Load.

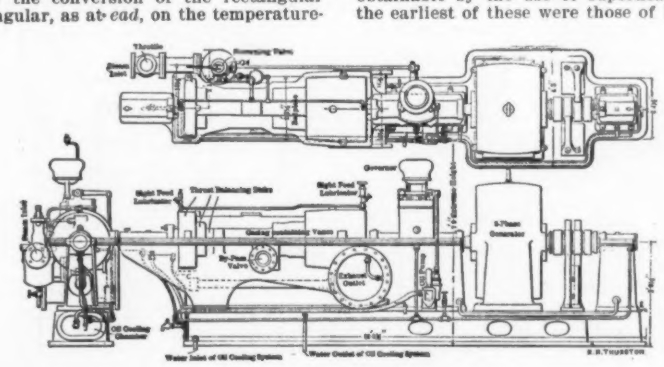


FIG. 14.

* "Manual of the Steam Engine," vol. i., chap. i., p. 484.

† Ibidem, chap. ix. and appendix; tales and examples. Also Trans. A. S. M. E., various papers on "Engine Efficiency," etc.

conditions of operation and of cycle. The consumption of steam was 27.6 pounds per electrical horse power at 95 pounds steam pressure, and with moist steam, in the earlier tests of 1891. The later tests here quoted exhibit decided gain by superheating; the figure falling to about 20 pounds with a superheat of 60 degrees Fahr.

In this case, jet-condensers were employed, giving about 28 inches vacuum; the speed of turbine was 4,800 revolutions per minute; the attached generator delivered an alternating current at 2,000 volts and /, at rated power, 60 amperes, with 80 alternations per second. Its electrical efficiency was 97½ per cent. The steam pressure at the boilers was 140 pounds by gage.

The following are the tabulated data obtained during these trials:

TABLE I.

GENERAL RESULTS OF TEST.

	Pressure by gauge on boiler.	Temperature of Steam.	Load in K-W. per hour.	Feed water per hour, Pounds.		
	Lbs. per sq. in.	Deg. F.		Total.	Per K-W.	Per E. H. P.
Continuous current moderate superheating.	96	335	0.1	480	....	....
	102	365	10.2	760	74.5	55.6
	100	356	27.0	1,110	41.1	30.7
	102	400	49.2	1,590	32.3	24.1
	100	390	74.5	2,170	29.1	21.7
	103	398	102.0	2,900	28.4	21.1
Continuous current, high superheating.	102	463	28.3	1,060	37.5	28.0
	102	468	49.5	1,480	29.9	22.3
	101	465	78.4	2,170	27.7	20.7
Alternating current, moderate superheating.	99	367	31.6	1,180	37.3	27.8
	97	394	49.9	1,550	31.1	23.2
	103	399	105.2	2,970	28.2	21.0

TABLE II.

CONSUMPTION OF FEED WATER AT VARIOUS LOADS.

Current output in K-W. per hour.	Feed Water Consumption per Hour, Pounds.			
	With Superheating to About 400 Degrees Fahr.		With Extra Superheating to 465 Degrees Fahr.	
	Per K-W.	Per E. H. P.	Per K-W.	Per E. H. P.
20	48	35.8	...	....
30	39	29.1	36½	27.2
40	34½	25.7	32	23.9
50	32	23.9	29½	22.0
60	30½	22.7	28½	21.3
70	29½	22.0	28	20.9
80	29	21.6	27½	20.5
90	28½	21.3	(27)	(20.1)
100	28½	21.3	(27)	(20.1)

The results of the trials are graphically exhibited in the diagrams, herewith shown, illustrating the variation of efficiency with load and its changes with variation of superheat; the one diagram exhibiting the variation of total feed-water demand and the second showing the change of the consumption for the unit of electrical horse power. The first illustrates the approximation to the "law" of Willans; the other the familiar curve of the common engine; while both exhibit the practical coincidence of method of variation and of actual expenditure with those of the piston-engine of good construction under equally favorable conditions of operation. It will be found, on examination of these results, that the amount of superheating required to prevent adiabatic condensation of steam, plus a small amount needed to supply the waste of heat from the working fluid through conduction and radiation from the exterior of the machine—in other words: that amount required to retain the steam in the dry, perhaps lightly superheated condition throughout its period of expansion within the turbine—is sufficient to insure this economy, and excess of superheat above this amount gives very little gain. The adiabatic liquefaction of steam and the flow of the liquid through the turbine, producing friction of notable amount, is found to be the only important reason for superheating in this apparatus, in which the expansion is necessarily adiabatic in the real p⁻ in the ideal case.

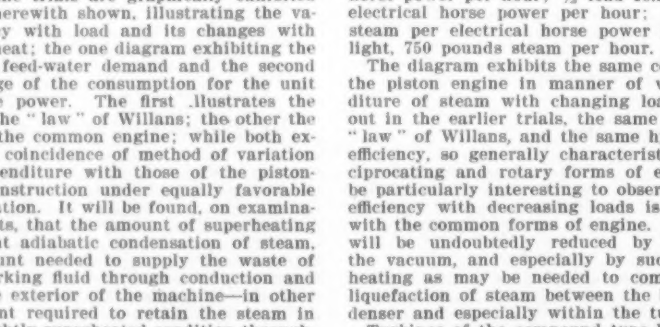


FIG. 15. STEAM CONSUMPTION OF 500 H.P. TURBINE SETS.

Recent trials of the Parsons turbine, as constructed by the Westinghouse Machine Company, in the United States, are reported to have given the following results. The engine is illustrated, with its connections to the generator, in the accompanying engraving. It is rated at 500 horse power, at 3,600 revolutions per minute.*

The steam-pressure employed was 125 pounds by gage, the vacuum 28 inches. The weight of the complete set, turbine and generator, is reported as 25,000 pounds, or 50 pounds per electrical horse power. The steam was practically dry during the trials, of which the following are the reported figures, reduced to graphical form in the usual manner in Fig. 15.

The following shows the economy of steam at several important points:

Full load 16.4 pounds steam per electrical horse power per hour; ¾ load 17 pounds steam per electrical horse power per hour; ½ load 18.2 pounds steam per electrical horse power per hour; ¼ load 22 pounds steam per electrical horse power per hour; running light, 750 pounds steam per hour.

The diagram exhibits the same correspondence with the piston engine in manner of variation of expenditure of steam with changing load as was brought out in the earlier trials, the same illustration of the "law" of Willans, and the same hyperbolic curve for efficiency, so generally characteristic alike of the reciprocating and rotary forms of engine; but it will be particularly interesting to observe that the loss of efficiency with decreasing loads is less marked than with the common forms of engine. Even these figures will be undoubtedly reduced by the perfection of the vacuum, and especially by such moderate superheating as may be needed to completely quench all liquefaction of steam between the boiler and the condenser and especially within the turbine.

Turbines of the compound type have been designed in various forms at Sibley College, and in some cases constructed and tested with some degree of success, both as to efficiency of turbine and as to improved state of the applied theory of the case.

One of these, an axial turbine, was designed by Mr. Thomas Hall, in part while abroad taking part with the Cornell crew in the Henley races, in June of that year, and was very similar to the turbine recently brought out by Curtis. It consisted of successive disks in each of which the jet was suitably altered in sections, velocity and direction, passing from disk to disk; *alternate disks moving in opposite directions* and thus acting each as the guide for the next; the one set keyed to a shaft turning in one direction, the other set to a drum turning in the opposite direction. This device reduced the needed number of disks by one-half; only ten being used where, otherwise, twenty would have been required. The turbine was of 10 horse power and consumed 60 pounds of steam per effective horse power per hour at 125 pounds boiler pressure and but 14 inches vacuum; the speed being made 6,000 revolutions per minute. Steam was delivered to the turbine from the jet at atmospheric pressure and at maximum velocity of flow. A second turbine was designed by the same inventor in the following year, June, 1897; and built that year. The first was an axial, the second a radial, turbine. In the latter, the steam was delivered through the shaft into the first of a pair of disks, revolving in opposite directions, carrying, each, concentric sets of buckets; the jet is thus taken alternately into oppositely moving buckets and the principle of the first construction is thus illustrated in the radial form of turbine. The speed, as before, was 6,000 revolutions per minute. The disks and buckets were made of phosphor-bronze. Some buckets were made by a process, since patented by Curtis, rolling bars and cutting off the length needed for each bucket. Developing 18 horse power, it demanded under test of 50 pounds of steam per horse power hour.

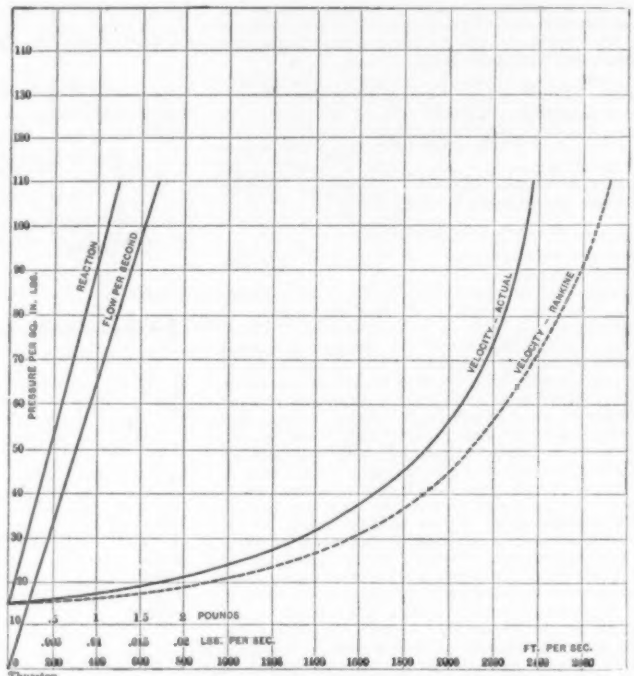


FIG. 16. ENERGIES AND VELOCITIES OF JET-DISCHARGE.

In later work, the buckets were made of an alloy of aluminium and zinc found to be particularly satisfactory for many purposes, and one which was discovered in the course of researches seeking to identify the "maximum alloy" of aluminium and zinc. It has been described already and has been frequently, generally used; in fact, in work of this sort in Sibley College, and notably in the researches of Dr. Durand on the efficiency of screw-propellers. It consists of two-thirds aluminium and one-third zinc. The corroding action of the jet of steam was too serious, however, and the buckets were later made of brass. The nozzles were made ¼-inch opening and given a taper of 9-64 inch to an inch of length.

Napier's formula was tested with a straight, short, nozzle with rounded entrance. Measures of impact-pressure were obtained by a series of experiments with specially constructed apparatus, and the familiar deduction was confirmed; the pressure on a bucket at rest being equal to that due the gage pressure. With straight nozzles, the jet expands, after leaving the tube, until atmospheric pressure is reached, when it retains a cylindrical form until broken up by air-currents. In the expanding nozzle, the jet has a minimum diameter, with low pressures, less than that of the exit orifice; with increasing tensions of steam, it moved outward and located itself at a point further from the extremity as the pressure rose. The work of the turbine itself was very satisfactory.

The results of the comparison of the computed pressures of the jet, and of the estimated deliveries, with the actual work in the case in hand are shown well in the accompanying curves (Fig. 16), as laid down by Messrs. Jones and Rathbone in a report dated June, 1898.

(To be continued.)

* Larger sizes, up to 2,500 horse power, are now under construction by the same builders.

POISONOUS GLAZED WARES.

A REPORT recently presented by the United States Consul at Mayence includes a warning to purchasers of silvered glass and porcelain which ought not to be overlooked. The silver is applied to certain kinds of this ware by a galvano-caustic process which involves immersion in baths highly charged with cyanide of potassium. The surface thus treated is not perfectly smooth, but is covered with innumerable fine cracks. In these the cyanide is absorbed and, it is said, cannot be removed during manufacture, although we should have thought, considering how extremely soluble cyanide of potassium is, that it could be easily washed out. As a natural consequence the use, even the handling, of the ware is apt to be followed by poisonous effects. One firm, it is stated, has abandoned this branch of manufacture because of the danger involved in it not only to the public but to the workmen employed. These glazed products are exported chiefly from Frankfort, Stuttgart, and Berlin. Until some non-poisonous means of plating the goods has been devised it is difficult to see how the very real danger which their use entails is to be avoided. No known process of after-washing can be relied upon to cleanse the minute cracks in the glaze, and even if this were possible, the position of the employes would not be improved. The German official authorities are not slow to interefere with manufactures which are proved to be injurious and they can doubtless be trusted to deal with this matter effectively. In the meantime the purchasing public will do well to regard the timely caution which we have quoted from the Times and to abstain from buying the articles in question.—The Lancet.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Development of the Zurich Tramways.—Most of the street railways of Zurich are owned by the municipality, and it is only a question of time when the few private lines still holding franchises will also be under the control of the city officials. Municipal ownership of street railways is gaining ground greatly in Europe.

The fare in Zurich is to-day 12.5 centimes (2.5 cents) when buying the tickets in block books, but will within the course of a few years be lowered to 10 centimes (2 cents). It is remarkable that the city can run the street railways so cheaply, considering the expensive and solid way in which the tram lines are constructed and the high price of soft coal, which costs from 33 to 40 francs ($6.37 to $7.72) per ton delivered at the power station.

During the years 1898-1900, the city of Zurich has changed its horse-car lines into electric lines with the overhead-trolley system, and also largely extended the mileage. The total length of track is now 40 kilometers (25 miles) and the number of cars 150, of which 40 are trailers. The electric lines have all been constructed by Mr. J. Sigfrid Edstrom, a Swedish engineer, who received his technical education in the United States. Mr. Edstrom, upon his arrival in Switzerland, found the electric street-car lines in a very bad state, in consequence of using inferior material. In rebuilding and extending the tramways of Zurich, Mr. Edstrom did his best to introduce American street-railway material. In buying the rails, however, he found that, owing to difficulties in the ocean transport, the American rails could be had only in lengths of 30 feet, while 60-foot rails were desired. As rails of this length could not be had on the Continent, it was finally decided to use Phœnix and girder rails (German) of 12 meters (40 feet) length. Without doubt, the American manufacturer of steel rails would have a great field for his overproduction if rails of greater length could be shipped across the ocean.

The electric rail bonds used in Zurich are from a New York firm. One of the new lines has been built with cast-welded joints without any electric bonds. The track itself is laid very securely on heavy stone or concrete foundations. The overhead-trolley wire is generally fastened to the houses, a special sound breaker being used to avoid the transmission of noises into the house. This arrangement is very satisfactory from an æsthetic point of view, as there are very few poles in the streets. Where houses could not be used, the wires are fastened to tubular steel poles of German origin, solidly fastened in concrete foundations. Many of these posts also serve as poles for gas or electric lamps.

The cars were built by two Swiss factories, but with Peckham (New York) trucks. The street-car motors and controllers are all of American manufacture.

The underground cables, as well as the electric generators, the steam engines, and the switchboard, are from Swiss factories. Several machines of American make are used in the repair shop.

Mr. Edstrom, the engineer in charge, has recently accepted a position as director of the tramways of Gothenburg, Sweden, where extensive construction of electric street-car lines will take place within the near future.—A. LIEBERKNECHT, Consul at Zurich.

Commercial Education in Saxony.—Nowhere in the world does commercial and technical education hold such a prominent place as in Germany, and of all the States which compose this Empire, Saxony takes the lead in this direction, says Ernest L. Harris, Consular Agent at Eibenstock. This little kingdom alone has about fifty handelsschulen, or commercial schools. These schools are in the first instance organized by the Kaufmännischen Vereine, or merchant unions, which exist in every little town in the country. The State exercises a supervising influence over each school. An inspector appointed by the government visits the schools periodically. The merchant union supports the school; but if there is any deficit at the end of the year, this is made good by the State. The buildings, together with light and heat, are furnished by the town authorities. In many cities of Saxony, handsome buildings have been erected for the purpose of commercial schools alone.

The average salary of the director and teachers depends upon their age and upon the size of the town. A director in a large city will get from $1,000 to $1,500. In the smaller cities, however, the salaries range from $600 to $800 per annum. All these teachers have been prepared for their work by completing either what we term a classical education or some thorough course without the classics, where more attention is paid to modern languages and business methods. It is the general belief that the latter course secures greater practical results in the schools.

Although the State regards these commercial schools with a certain benevolence, it has thus far made no solid provision for the teachers. In every common village school throughout the German Empire, the teachers know just what they have to expect. There is a stable system of promotion, together with a pension after so many years of service. This is not the case with teachers in the commercial schools, and this fact does much to deter the healthy development of the schools, inasmuch as it prevents many able teachers from entering them. However, teachers in the commercial schools of Saxony are pensioned after years of service, while in Prussia no pensions are granted.

The students who attend these schools come from families of the middle class. They are apprenticed to merchants during their whole attendance at school. Their ages vary from fifteen to eighteen. The law governing the relations between master and apprentice is very strict, and while the pupils are in attendance at school the director takes the place of the master. A number of commercial schools in Saxony takes only students who devote their whole time to attendance; but the majority have apprentices who spend half the time in some business house. The latter plan has been found to be conducive to better results, owing to the opportunity of combining theory with practice.

There is some complaint made on account of the disposition of many merchants to employ clerks who have not completed the full course of two years. There is no doubt that the merchants could greatly assist these schools if they insisted on hiring only young men who had certificates or diplomas from commercial schools.

For a small city, the commercial school of Eibenstock is a model of its kind. It occupies spacious rooms in a large industrial school building and has a director and several teachers. As it is typical of all the other commercial schools in Saxony, I give the scheduled course in detail:

Forenoon.

Monday.—Calculation, bookkeeping, French, English.
Tuesday.—English, typewriting, French, calculation, commercial correspondence.
Wednesday.—Stenography, calculation, bookkeeping, commercial correspondence.
Thursday.—English, French, calculation.
Friday.—Geography, correspondence, French, English.
Saturday.—English, calculation, French.

Afternoon.

Monday.—German, French.
Tuesday.—Geography, calculation.
Thursday.—Writing, French.
Friday.—German, commercial correspondence.

This plan speaks for itself. Noticeable, however, is the time devoted to English and French. Through the courtesy of the director and board of trustees, I was permitted to attend the exercises for several days. It is astonishing with what rapidity and precision the young students dash off sentences in English and French. During the second year, the hours devoted to these languages are taken up entirely with conversation and readings, and not a word of German is heard. During the hours devoted to calculation, the currency, together with the measures and weights, of every country in the world is taught, and the students are compelled to make rapid mental calculations in them all. Outside of school hours, the apprentice is kept busy looking after the English and French correspondence of his chief and in learning that particular trade or business of the house to which he is apprenticed. After business hours and in the evenings, he must prepare for the next day's school.

During the winter, the director of the Eibenstock commercial school delivers to his students a series of six lectures, to which the public is invited. These lectures deal entirely with questions relating to trade and the development of commerce. At each one of these meetings, a student must prepare and deliver a short talk on some given topic.

In 1898, a commercial university was established in Leipzig. Only those are eligible to entrance who have completed the gymnasium course or have passed the examination which admits to the one-year conscription service in the army. There is an attempt at present to make the diploma or certificate of the commercial school equivalent to the certificate of the one-year army service, but as yet nothing has come of it. Should this be carried through in time, the students of all the commercial schools would be eligible to the university.

Inasmuch as the Commercial University in Leipzig has excited a great deal of attention and students from all parts of the world have gathered to hear the lectures, I give for the benefit of American students and others interested the course of lectures given during the summer semester of 1900: Political economy; history of political economy, including socialism, money, banks, and the bourse; commercial law, introduction to the study of statistics, German colonial politics, insurance, development of German commerce, chemical technology, development of the foreign commerce of all nations, science of finance, international law, elementary lessons in Chinese grammar, lectures on China and Japan, lectures on the languages and customs of the people of Indo-China, history of the papacy during the Middle Ages, introduction to philosophy and logic, history of German literature, history of England as a world power from 1500 to 1900; physical geography, natural philosophy, and physics; history of the development of education in Germany, state and church in the nineteenth century, comparative history of the colonies of the different European states, constitutional history, pedagogy; natural history, hygiene, etc.; lectures on travel.

In addition to these lectures, there are exercises in bookkeeping, correspondence, and office work, with commercial arithmetic. There are also Handelsseminaren, where professor and students meet once a week for the purpose of discussing questions relating to trade and commerce. Instruction with commercial correspondence is given in the following languages: English, French, Italian, Russian and Spanish. In addition, arrangements are made for instruction in the German language and correspondence for foreigners.

Thus it will be seen that the student has a very broad field from which to choose those subjects which interest him most. It must be remembered that the Commercial University is connected with the university proper, and that a great many of the above-named lectures have long been established courses in the regular curriculum.

It is natural to suppose that the majority of future directors and teachers in the commercial schools will be chosen from the ranks of those who have completed a course in the Commercial University. But the practicability of this scheme is yet to be demonstrated, as most of the eligible students have had very little, if any, actual experience.

Fraudulent Letters from Spain.—Minister Storer writes from Madrid, November 21, 1900, in regard to schemes to defraud Americans, which take the form of letters from parties in Spain informing them that property is awaiting them, or that relatives are being detained in prison, and asking for money to cover expenses in the matter. Mr. Storer says that he has had to write so many letters on the subject, since his arrival in Madrid, that in self-defense, the legation has been compelled to have blank forms of reply and warning printed for use. The minister continues:

Nine out of ten of these attempts to victimize give the name of the supposed prisoner or deceased, as the case may be, with the addition of the family name of the person addressed. Sometimes the further assertion is made that a daughter—a little girl—is kept in a convent and needs clothing or supplies. Her photograph is often inclosed. We have had four photographs sent here for us to identify. Sometimes the prisoner has valuable furniture or plate, a list of which on official stamped paper is inclosed; or has died leaving a will, of which a stamped-paper copy, countersigned with forged court seals, is sent, in which the chaplain of the prison is made executor, who will transmit the property if the necessary expenses are forwarded to some address. Sometimes vast sums of money lie buried in Cuba, the exact spot being known only to the chaplain and notary attending the prisoner at his last moments. Often newspaper clippings, ostensibly from Spanish newspapers, giving an account of some such matter, are inclosed.

A large number of these forgeries, drawn on regular government stamped paper, have at different times been transmitted by me to the Spanish government, and I have personally urged the Ministry to exert itself to ferret out these flagrant and open swindles.

The same scheme is in operation in regard to Great Britain, Germany, and Russia.

I regret the number of American citizens who have wasted their time in paying any attention to these letters, and still more the fact that many have allowed themselves to send money and even undertaken the voyage in the hope of getting property to which they had not the slightest claim.

I ask the Department to give the greatest possible publicity to this long-continued and vexatious swindle.

American Steel in Germany.—Writing from Frankfort, November 20, 1900, Vice-Consul-General Hanauer says:

Mr. Wiegand, the director-general of the North German Lloyd Steamship Company, at a public festival last week, made a speech in which he defended his company against the attacks made on it by German industrial circles on account of the company's late purchase of 1,000 tons of steel in the United States. The director said:

"We have, during the six years past, paid to German industries over 130,000,000 marks ($30,940,000)—i. e., about 22,000,000 marks annually. The order given to American steel works, amounting to about 300,000 marks, is insignificant compared with these figures. It is not to save 10 per cent in price that this order was given to a foreign concern, but the Lloyd company would not have reached its present position had it not utilized the improvements offered by outside manufacturers. We would like to see German industry brought to the utmost tension by foreign competition and not afraid to meet it at home; thereby the only possibility exists for us to maintain our place in the international contest for economic fitness."

Industrial Concerns in Germany.—Consular Agent Harris writes from Eibenstock, November 13, 1900:

There are at present in Germany 296 great industrial concerns which employ more than 1,000 persons each. The total number of persons employed by them amounts to nearly 600,000, and the machinery in use represents nearly 700,000 tons horse power. The most important concern is the Krupp Works, in Essen, where 44,087 laborers are employed. Next to this comes the Hamburg-American Steamship Company, which employs 14,643 persons on sea and land.

New Bank in Asuncion.—The Department has received from Consul Ruffin, of Asuncion, a report in regard to the establishment, in that city, of a new bank, called "Caja de Credito Comercial," whose purpose is to promote local and foreign commerce. They will be pleased to facilitate all commercial and financial operations between Paraguay and the United States. The managers, says the consul, are active and desire to have their organization brought to the attention of our bankers and merchants. They invite correspondence. Copy of the statutes, sent by Mr. Ruffin, has been filed for reference in the Bureau of Foreign Commerce.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Ceresine Paper.—For the production of ceresine paper, saturate ordinary paper with equal parts of stearine and tallow or ceresine. If it is desired to apply a business stamp on the paper, the paper, before saturation and after the stamping, should be dried well for twenty-four hours, so as to prevent the aniline color from spreading.—Neueste Erfindungen und Erfahrungen.

Fly Cornets are prepared, according to Seidler, by melting together 2 parts of colophony, 1 part of linseed oil and 1 part of transparent turpentine, and applying the mass while yet warm on ceresine paper by means of a brush, leaving the edges free. Lay a second sheet upon the first coated one, which had best be placed upon a heated tin, and distribute the mass evenly upon them by means of a noodle rolling pin. The cornets are then pasted together in a suitable manner with the uncoated edges.

Bottle Wax.—Many ready-prepared solutions, such as developers and other preparations from which light has to be excluded, should be packed in bottles whose neck, after complete drying of the stopper, is dipped in a pot with molten sealing wax. A good receipt is the following, pigments being added if desired: For black take: Colophony, 6 grammes; paraffine, 3 grammes. Melt together and add 20 grammes of black. For yellow, only 7 grammes of chrome yellow. For blue, 7 grammes of ultramarine.—Deutsche Photographen Zeitung.

Black Leather Color and Regenerator.—

Methylic alcohol	22½	liters.
Ground ruby shellac	2.250	kilo.
Dark rosin	0.910	"
Gum resin	0.115	"
Sandarac	0.115	"
Gas black	0.115	"
Aniline black spirit-soluble	0.115	"

The gums are dissolved in spirit and next the aniline black soluble in spirit is added; the gas black is ground with a little liquid to a paste, which is added to the whole, whereupon filter.—Neueste Erfindungen und Erfahrungen.

Steatite for Paint.—A material known under the names of lardite, steatite, agalmatolite, pagodite, is excellently adapted as a substitute for the ordinary metallic protective agent of the pigments and has the property of protecting iron from rust in an effective manner. In China, lardite is used for protecting edifices of sandstone, which crumbles under the action of the atmosphere. Likewise a thin layer of powdered steatite, applied in the form of paint, has been found valuable there as a protector against the decay of obelisks, statues, etc. Lardite, besides, possesses the quality of being exceedingly fine-grained, which renders this material valuable for use in ship painting. Ground steatite is one of the finest materials which can be produced, and no other so quickly and firmly adheres to the fibers of iron and steel. Furthermore, steatite is lighter than metallic covering agents, and covers, mixed in paint, a larger surface than zinc white, red lead or iron oxide. Steatite as it occurs in Switzerland is used there and in the Tyrol for stoves, since it is very fireproof.—Munchener Bauzeitung.

Exclusion of Air from Solutions.—Many solutions spoil too quickly or decrease in strength by an imperfect exclusion of air. Much of this might be prevented in the preparing. Many operators who imagine they are conscientiously following the direction to use only boiled-out water for preparing developers, only heat until the first gas bubbles rise. But it is these little gas bubbles which should be entirely removed. Water is only free from air when it has been maintained for several minutes in bubbling ebullition. In order to keep out the air from the bottle, when using the contents, the air-pressure contrivances are very convenient; one glass tube reaching through the rubber stopper into the bottle to the bottom, while the second tube, provided with a rubber pressing-ball, only runs into the flask above. If the long bent tube is fitted with a rubber tube, a single pressure suffices to draw off the desired quantity of the developer. It is still more convenient to pour a thin layer of good sweet oil on top of the developer besides. The developer is not injured thereby, and the exclusion of air is perfect.—Deutsche Photographen Zeitung.

Heat-Insulating Agents.—The most varying heat insulators are offered for sale and this keen competition shows how anxious factory owners are to prevent all loss of heat, by covering up their steam pipes. Of all bodies, air in motion possesses the best heat-conducting capacity. If the steam conduits and steam vessels are free and exposed to the air they give off considerable quantities of heat by radiation, because the air, constantly in motion, incessantly carries off hot air and supplies fresh colder air. When the pipe is only covered with a board partition, thus preventing the supply of fresh air, the loss of heat by radiation is much lessened. The thicker the covering around the steam pipe, the more heat is retained. A chief requirement for such protective mass is that it contains air in fine canals, so that there is no connection with the closed-in air. Most substances suitable for insulating are such that they can only with difficulty be used for a protective mass. The most ordinary way is to mix infusorial earth, kieselguhr, slag-wool, hair, ground cork, etc., with loam or clay, so that this plastic mass may be applied moist on the pipes. In using such substances care should be taken to carefully clean and pre-warm the surfaces to be covered. The mass for the first coating is made into a paste by gradual addition of water and put on about 2 to 3 mm. thick with a brush. After letting dry each time, a further coating is taken in hand. This is repeated until the desired thickness is reached. The last layer put on is rubbed smooth with the flat hand. Finally, strips of linen are wound around, which is coated with tar or oil paint as a protection against outside injuries. Cork stones consist of crushed cork with a mineral binding agent, and are furnished pressed into various shapes.—Papier Zeitung.

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